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A PROPOSED PLAN FOR REBUILDING THE BROOKLYN BRIDGE.

"The present Brooklyn Bridge was never intended and dimensioned for the traffic it now has to carry. The suspended structure, from anchorage to anchorage, about 3,500 ft. long, is in a wornout and weakened condition, requiring constant and expensive repairs to keep it safe. The rebuilding of the bridge has become imperative." These statements, by Mr. Gustav Lindenthal, M. Am. Soc. C. E., late Commissioner of Bridges of New York city, express tersely the problem which the famous old Brooklyn Bridge presents to its custodians and to the people who use it in their daily journey between Manhattan and Brooklyn. Sooner or later the bridge must be rebuilt, and no one who is familiar with the conditions can doubt that it will be the part of wisdom to hasten the task as much as is possible. The work cannot be commenced until it is possible to relieve the bridge of a large portion of its present traffic, and this will not be for some years to come, but it is none too early to begin preparations for the work by canvassing the possible solutions of the problem and choosing the one which seems best to meet the requirements. It is for this reason that we make space in this issue for the plans for reconstruction suggested by Mr. Gustav Lindenthal before retiring from the office of Commissioner of Bridges on Jan. 1, 1904. The report made by Mr. Lindenthal to accompany his plans is, nearly in full, as follows:

In order that the rebuilding of the Brooklyn bridge may be taken in hand without delay when the Manhattan bridge shall have been completed, I have prepared such preliminary plans and specifications as can be used as a basis for more detailed plans and studies, which, as a rule, require considerable time, so that an early beginning is desirable.

I find it practicable to convert the present old structure with one deck, into a new structure with two decks, arranged to accommodate four elevated tracks and two trolley tracks. The latter will be entirely separated from the roadways, each of which will be 17 ft. wide. That will make it possible to run trolley cars over the bridge at twice the speed of the present limit. It means that a pair of trolley tracks on which at present 300 cars per hour can run, will then be able to accommodate as many as 400 to 450 surface cars per hour, in and out during rush hours. That number is probably the limit of cars per hour that could be drained into the streets radiating from the Brooklyn end of the bridge, without causing congestion of street traffic during rush hours.

Greater relief and more rapid transit must be obtained by elevated railroad trains, for which four tracks are provided, in place of the present two tracks. The capacity of the rebuilt Brooklyn bridge will thus be nearly doubled for rapid transit, besides restoring to their former width the two roadways for wagon traffic, and adding two promenades for pedestrians. There will also be more space for telegraph wires, postal tubes and other equipment on the bridge structure.

The accompanying plans show the proposed reconstruction. They comprise not only the rebuilding of the superstructure, but also the enlargement of the anchorages, which, otherwise, would be too light.

It is intended to place stairways and elevators at each anchorage, to make the bridge accessible from the streets below. The stone towers will be somewhat heightened in order to provide a roof for the masonry, and to make the cable bearings more accessible for inspection. At present the top of the tower is accessible only with great difficulty, and not without danger.

The roadways will be fireproof. They will have a steel channel foundation, with wooden-block paving. Throughout, the structure is intended to be modernized and brought up to a condition where its maintenance (which is now very costly) may be reduced probably by one-half; that is, to the mere painting of the ironwork and the repair of the tracks and wood-block pavement.

The present cross-section of the bridge is shown by Fig. 3, and the proposed cross-section by Fig. 4. The present structure has a capacity of two elevated tracks, two trolley tracks, leaving two narrow strips of less than 9 ft. each on each roadway for truck traffic, and one promenade, 15 ft. in width. The live load for which the bridge was originally designed is about 2,000 lbs. per lin. ft.

The reconstructed structure will have accommodations on the upper deck for four elevated railroad tracks, and on the lower deck for two trolley tracks, two paved roadways, 17 ft. each, and two promenades, each 8½ ft. wide in the clear. The present width of the bridge is 86 ft.; the width of the reconstructed bridge will be 105½ ft.; the capacity of the new bridge will be 11,000 lbs. The live load per lin. ft. of bridge is as follows:

	Lbs. per lin. ft.
Two rapid transit trains, at 1,700 lbs.	3,400
Four lines trolley cars, at 1,000 lbs.	4,000
Available width of roadways and footwalks, at 70 lbs. per sq. ft.	3,570
Total	10,970
Say	11,000

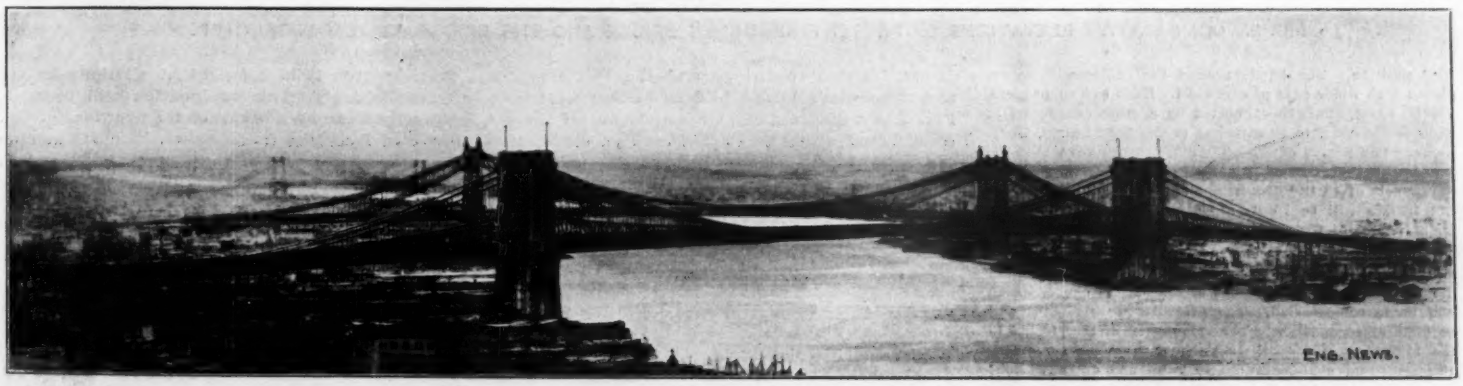


FIG. 1. VIEW SHOWING EXISTING AND PROPOSED BRIDGES ACROSS THE EAST RIVER AT NEW YORK CITY.

(The bridge in the foreground is the old Brooklyn Bridge as it would appear after reconstruction. The structure close behind it is the proposed Manhattan Bridge as it would appear if constructed with eye-bar cables. The Williamsburg and Blackwell's Island Bridges are seen in the distance.)

The leading considerations in the laying out of the plan were:

(1) No additional cables shall be required.

(2) No additional load shall be put upon the top of the towers which would bring a higher pressure upon the masonry than would be considered prudent.

(3) The bridge shall be safe under a congested maximum live load wherever it may occur on it between the anchorages. The existing bridge has not been designed for that condition, and would not be safe if a local congestion should occur on it anywhere between anchorages.

(4) The weight of the stiffening frames shall not be carried by the cables, which would considerably increase the strain in the latter and reduce the stability of the anchorages.

(5) The cables shall carry practically the entire live load and also the weight of the floor construction proper.

(6) The stiffening trusses shall carry their own weight and the wind and lateral bracing.

(7) In order to make this distribution of dead and live load upon the cables and the stiffening trusses an absolute certainty, the stiffening trusses shall be designed as continuous trusses over the towers, with fixed pier bending moments to be described hereafter.

(8) Anchor posts will be placed under the middle of each

span. They will act as anchors for the continuous girders of the middle span, and as supports for the live load on the side spans. The expansion joints will be placed near those anchor posts.

In order to keep the dead weight of the new structure within the lowest practicable limits, nickel steel has been selected for the stiffening trusses. There appears no particular saving in weight in the use of nickel steel for the floor construction, and structural steel will here fully answer the purpose.

The stays of wire ropes running over the top of the towers to the present stiffening trusses will be removed, being a troublesome feature and a useless weight on top of the towers. The present wind wire ropes will also be removed. The new trusses and their lateral bracing will effectively sustain any possible wind pressure.

It is desired to use the present suspenders from the cable and to maintain the cables in an inclined or cradled position. The bands around the cables will be replaced with wider ones of cast steel. Each two suspenders, 7½ ft. apart, shall be connected by a cross connection at their lower ends, to be attached to the floor beams, 15 ft. apart. The panels of the stiffening trusses have been divided with that view into lengths of 30 ft. each, with two sub-panels of 15 ft. The height of the continuous stiffening trusses will be 75 ft. at each tower, reducing to 19 ft. at center of main span and at anchor posts.

The constant pier bending moments at the towers in the stiffening trusses will be produced by a hydraulic piston arrangement between the ends of the bottom chord, which will be in compression. The pressure at this point will be maintained constant. The calculation of the strains in the stiffening trusses thereby becomes much simplified. The stiffening changes sufficiently up and down without causing considerable strains in the chords.

The weight of the stiffening trusses at the towers is carried down by steel posts inside the hollow space in the existing stone towers directly to the tower foundations, which are amply strong to take this load.

The full congested load upon the bridge will be an extremely rare event, and for that reason high unit stresses, within 10% of the elastic limit in the stiffening girders, can be safely assumed.

The design is so laid out that the bridge can be reconstructed without much disturbance of the traffic over it. Nevertheless, it should not be undertaken until the Manhattan bridge shall have been completed. The arrangement of the stiffening girders in the end span is such that the anchor arm extending from the tower meets the anchor arm extending from the anchorages, which shall be constructed as a cantilever.

The anchorages require lengthening to increase the resistance to sliding and to prevent a large increase in the present toe pressure from the increased pull upon the cable. The plans show how this lengthening of the anchorages is to be effected, leaving at the same time room for stairways and elevators at this point.

The foundation upon which the anchorages stand is on both sides a fine, compact sand, and so far has proved to be stable and satisfactory. But in order to be quite safe, steel sheet piling should be driven all around the foundation of each anchorage to protect the same against injury from excavation that may happen in the future in its neighborhood, either for the construction of houses, sewers, or water pipes.

An approximate estimate of cost for the work outlined above, from anchorage to anchorage, and including the same, is.....	$5,141,000
For extending the elevated railroad lines to the terminals at both ends, and repaving the roadways and sidewalks, etc., the same estimate is	357,000
This gives a total estimate cost of.....	$5,498,000

A more accurate estimate will be, of course, possible when the detail plans and full estimates will have been made.

The accompanying drawings illustrate the more important structural features mentioned in the above report. Fig. 1 is a reproduction from a wash drawing of the Brooklyn Bridge as it will appear if reconstructed. It also shows the adjacent Manhattan Bridge and the Williamsburg and Blackwell's Island bridges farther upstream. Fig. 2 is a diagram elevation and plan of the reconstructed Brooklyn Bridge. The anchorages are enlarged, the inclined stays are obliterated and the old stiffening trusses are replaced by others of cantilever form. The changes wrought in the cross-section of the bridge by the new plans are clearly shown by Figs. 3 and 4.

The most noteworthy features of the design for reconstruction are the stiffening trusses. These, as is stated in the report given above, were designed so as to be self-supporting, and so as to act also as stiffening trusses to distribute the live load to the cables. To make the trusses self-supporting they are built as cantilevers continuous over the towers with the shore arms anchored down as shown by Figs. 2 and 5, and with the river arms meeting at the middle of the bridge. The pier moment of each truss due to dead load is then made constant by replacing a section of the lower chord over the pier with a hydraulic jack connected to an accumulator under constant load. The effect of this is of course to throw any load except that due to the weight of the truss itself, that is, any live load, onto the cable system. None of the weight of the truss is so transferred, however, because it is balanced at all times by the hydraulic jack. This explanation will be made perfectly clear by a study of the drawings of Fig. 6, which show the truss construction at the towers, and by the text of the report which is given above.

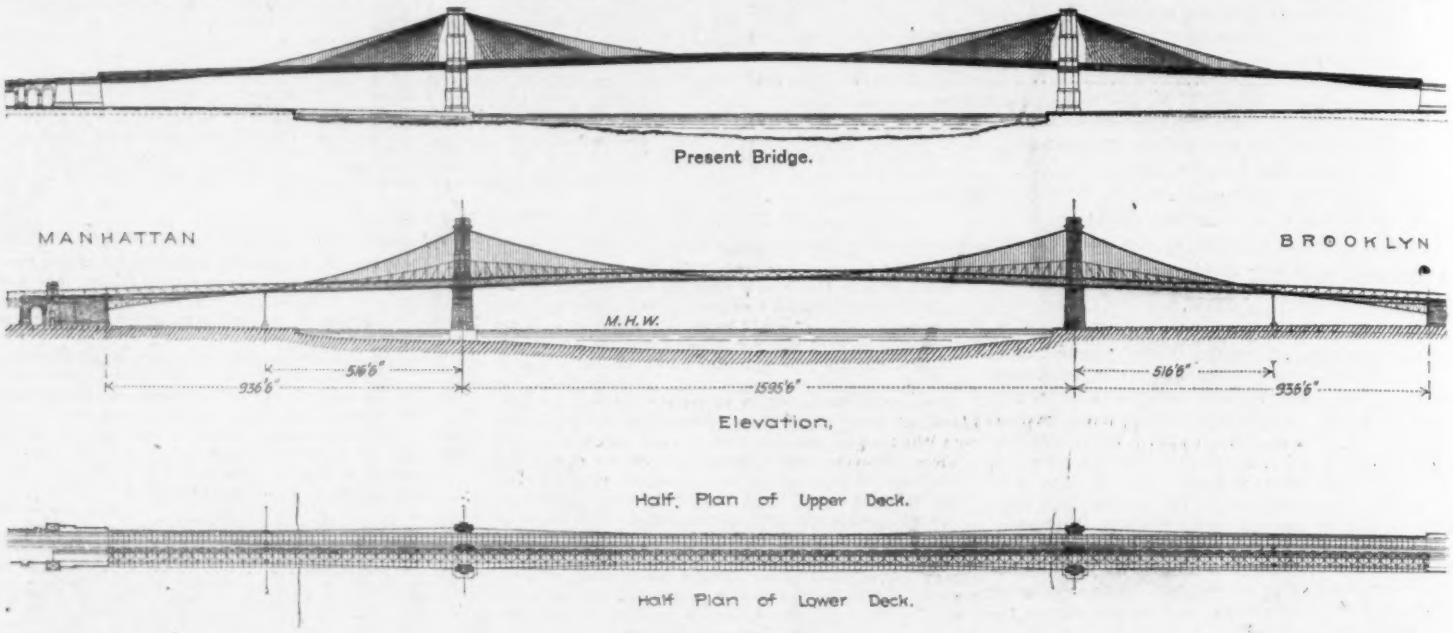


FIG. 2. COMPARATIVE ELEVATIONS OF PRESENT BROOKLYN BRIDGE AND THE BRIDGE AS RECONSTRUCTED.

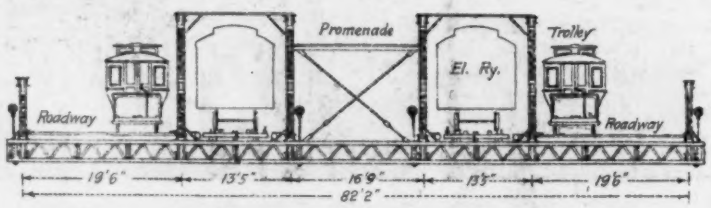


FIG. 3. CROSS-SECTION OF PRESENT BROOKLYN BRIDGE.

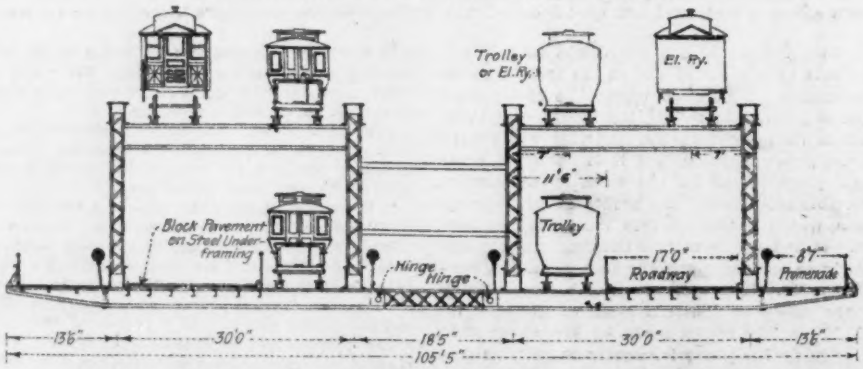


FIG. 4. CROSS-SECTION OF BROOKLYN BRIDGE RECONSTRUCTED.

The designs for the reconstruction of the Brooklyn Bridge, as already stated, were prepared by the engineers of the Department of Bridges under the direction of Mr. Gustav Lindenthal, M. Am. Soc. C. E., Commissioner of Bridges of New York

city. The architectural features were worked out by Mr. H. Hornbostel, Architect for the Department.

THE DEVELOPMENT OF STEEL FREIGHT CARS IN THE UNITED STATES.

Steel car construction in this country dates back only about 10 or 12 years, but in foreign countries such cars have been in general use for 20 to 25 years. Within the past six years, however, there has been a rapid and remarkable development in the use of steel in car construction on American railways, and it will be of interest to review briefly the course of this development, and also to show the action of the Master Car Builders' Association in regard to this phase of the development of freight car design and construction. In another column we have reviewed the present situation of the steel car question.

In 1890 and 1891, the railways were experiencing considerable trouble from the breaking of car sills, owing to the increase in car loads and in power of locomotives, and the use of steel sills and underframes began to be considered as a practical necessity for future development. The use of pressed steel parts began in 1888, when a stake pocket was introduced, and early in 1891 a paper on "Pressed Steel in Car Construction" was read by Mr. C. T. Schoen before the New York Railway Club (Engineering News, March 28, 1891). This referred mainly to pressed steel parts (spring plates, center plates, stake pockets, etc.), but contained the following statement:

> The Harvey Steel Car Co. is building 25 of its steel cars. The Fox Pressed Steel Co. is developing its pressed steel truck. The Schoen Mfg. Co. is making preparations to build a number of steel cars, and proposes to put them in service and let them run to develop any weak parts, with a view to preparing to build these cars in a regular way. It is confidently believed that a steel gondola car of 30 tons capacity can be built thoroughly well and weigh less than 19,000 lbs., a saving in weight of several thousand pounds over the ordinary wooden car. It is fair to presume that the cost for maintenance would be less than in a wooden car. The constant reduction in cost of steel and the growing scarcity and consequent increase in cost of timber, the reduction in dead weight, and the probability that it will last twice as long as a wooden car, are strong reasons why all developments looking to the introduction of a steel car, in whole or in part, should be viewed with interest by railway men and investors.

The new pressed steel works of the Schoen Mfg. Co. were opened in 1891, but it was not until 1897

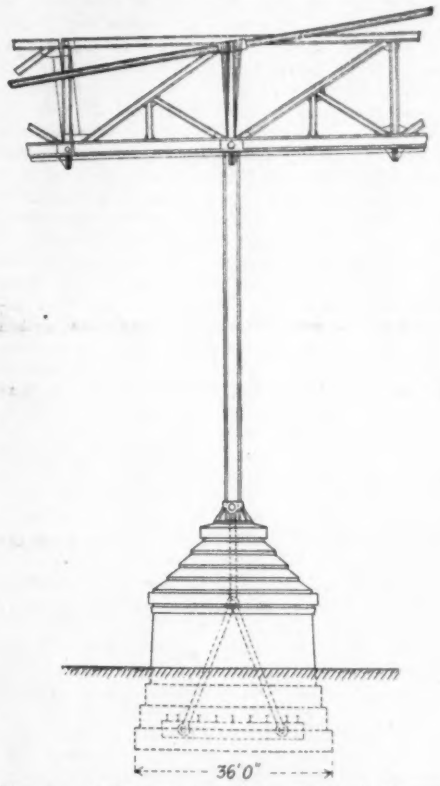


Fig. 5. Anchorage for Shore Ends of Proposed Cantilever Stiffening Trusses for Reconstructed Brooklyn Bridge.

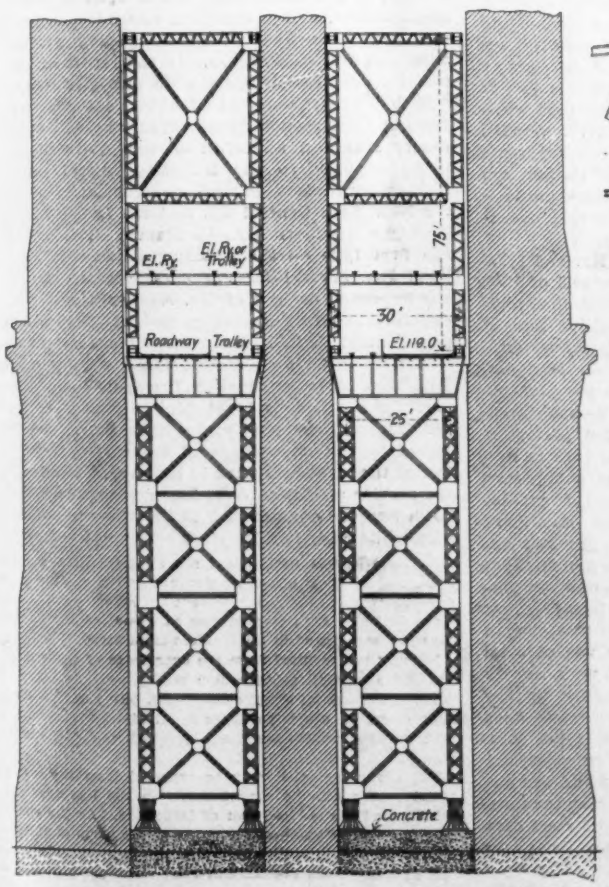
that its cars were built. In that year 500 cars were built, and over 100,000 cars of this type have since been built and put in service. In our issue of July 11, 1891, it was pointed out that there had been a decided increase in the use of steel in car construction, while "the manufacture of cars entirely of steel has been frequently suggested." The Harvey Steel Car Co. started its works in 1891, and built a number of box, flat and coal cars of steel, and in our issues of July 11, 1891, and May 19, 1892, we described the Harvey steel stock cars, some of which were built for the Chicago, Milwaukee & St. Paul Ry.

In January, 1892, the late D. L. Barnes, in a paper read before the Western Railway Club, reviewed the improvement in freight car construction during the past twenty years, showing that although wooden frames were as heavy as it was economical to make them, the sills were breaking because they were too weak to stand the shocks and strains of service. He stated that a steel underframe could be made having more than twice the strength and only about half the weight of the wooden frame. At that time European cars were generally built with steel or iron underframes, and similar frames were used in Mexico. "In this country, iron pipe sills and composite sills have been tried and found wanting; the Harvey steel underframe is probably the best that has been tried here." Repairs on metal frames were reported to be light, and metal frames which had been in service for 15 or 20 years on German railways appeared as good as when first put in service. He thought that the introduction of steel car framing in this country was hindered by the enthusiasm of its advocates, who generally advocated too radical a change. He also considered a wooden floor necessary, and thought that a metal superstructure (floor, siding and lining) would not be in general use until long after metal sills had become common.

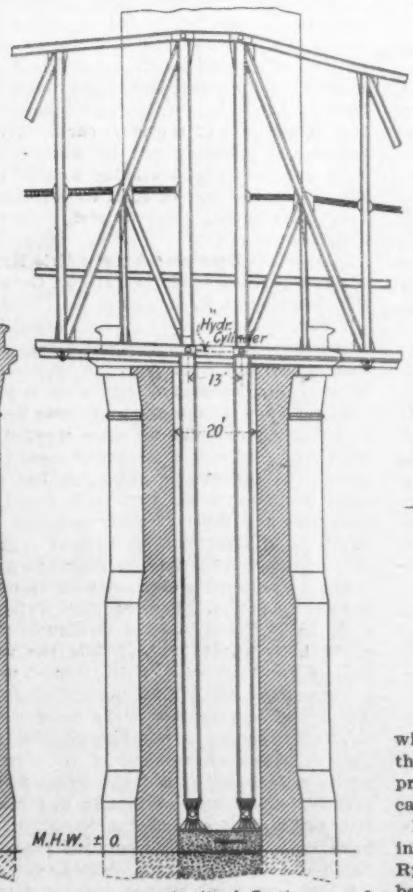
The economics of the steel car in regard to transportation service were discussed at some length in our issue of May 19, 1892, when the following prediction was made:

> These facts lead us to believe that steel car construction has come to stay, and to rapidly increase. The next development may well be 12-wheel cars of about the size of baggage cars, and with much better springs under them, so as to be fit for occasional high speed, and with a capacity of perhaps 100,000 lbs. With such cars, all equipped with train brakes and close couplers, and handled down grades and on levels at any handy speed up to 40 miles per hour, freight rates may touch depths not dreamt of yet, and still leave a larger profit on each ton handled than is realized to-day.

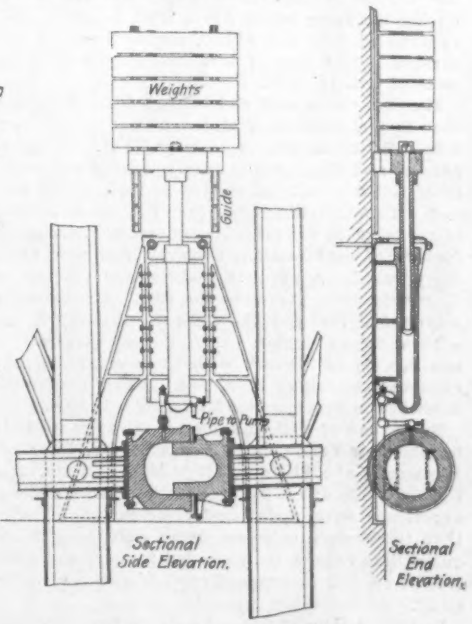
This prediction has been fulfilled in every item,



Transverse Section through Existing Masonry Tower.



Longitudinal Section through Masonry Tower.



Hydraulic Cylinder, Enlarged.

FIG. 6. DETAILS OF STIFFENING TRUSS CONSTRUCTION AT TOWERS.

with the exception of the six-wheel trucks, and the fact that there is still room for further improvement in spring equipment for cars of large capacity.

In 1893, some of the Harvey steel cars damaged in a wreck on the Chicago, Milwaukee & St. Paul Ry. were sent to the builders' shop, where the bent parts were removed, straightened and put back again. In the later Harvey cars special

care was taken to so design them as to simplify and cheapen the removal of parts for repairs. Some of the first cars were in three wrecks during two years' service, and it was found that it would have cost more to repair the bodies than to build new ones. The reason for this was that the parts were not interchangeable, and too many rivets were used. This experience therefore led to modifications in the design with a view to interchangeability of parts and to greater facility in repairs and renewals. These cars were built of standard market sections of structural steel, and bolts were largely used instead of rivets. At the Columbian Exhibition in Chicago, in 1893, the Harvey Steel Car Co. exhibited a gondola car, a box car, and a steel frame for a tank car. The Fox Pressed Steel Co. also exhibited a flat car with pressed steel sills, truck frames, etc.

For some years persistent attempts were made to introduce cars having a type of metal underframe in which each sill was composed of a pair of tubes, one above the other, and with metal spacing blocks and connections. A number of such cars were put in service, but did not prove satisfactory, largely on account of the great number of parts and the lack of stiffness and rigidity, as well as of strength. In 1891 a few of these cars were in service, but in 1894 the manager of the company owning them stated that about 8,000 box, gondola and flat cars of this type were in service. All of these were only leased to and not owned by the railways, but the cars are now obsolete and out of service. In 1893 a committee of the Master Car Builders' Association reported as follows:

A considerable number of cars have been built with iron pipe underframes, but these are scarcely practicable and are not of a type that would ever be generally used.

Some flat cars of this type were leased by the Norfolk & Southern Ry. in 1888, and after five years' service were in godd condition (Eng. News, Feb. 1, 1894). They were, however, too lightly built, and were not able to stand the more severe shocks incident to the introduction of heavier engines and improved draft rigging. Certain members were too weak, and the number of parts gave trouble in service and in making repairs. The road is a small one and more than ordinary care was taken in the handling of trains, so that the cars were operated under favorable conditions. The repairs for 50 iron cars and 50 wooden cars during the three years, April, 1890, to April, 1893, aggregated $406 and $4,265, respectively. A discussion of this type of cars was published in our issue of Oct. 11, 1894.

The experience with these cars led Mr. Joughins, then Superintendent of Motive Power of the Norfolk & Southern Ry., to design a 34-ft. flat car of heavier and simpler construction, composed mainly of rolled structural shapes and plain forgings, and with all parts put together with bolts instead of rivets, as in the later Harvey cars. This latter feature of construction, however, has now quite disappeared. A peculiar feature was the use of diagonal bracing between the sills. The capacity was 80,000 lbs. and the light weight 20,300 lbs. without brake rigging. One of these cars was in use for 4½ to 5 years without any repairs, not even the tightening of a bolt. These cars were described in Engineering News, Feb. 1, 1894.

By the end of 1894, a number of railways (including the New York Central, Pennsylvania, Norfolk & Western, Lake Shore & Michigan Southern, and Chicago, Milwaukee & St. Paul) had had sufficient experience with metal underframes to indicate that these were stronger, more durable and required less repairs than wooden frames, while the cost of repairs to wrecked steel frames was quite small.

In 1896, a type of flat car construction in which pressed steel shapes were employed was invented by Mr. Pennock, and the firm of Pennock Bros. built for the Carnegie Steel Co. a 60,000-lb. flat car of this type, weighing 22,620 lbs. The floor was composed of seven longitudinal pressed steel channels, laid with the flanges downward, the adjacent flanges being riveted together and forming the sills. In 1897, the Pennock patents were acquired and the designs improved upon by the Universal Construction Co., which also acquired the Harvey steel car patents. This company built several cars, and the improved Pennock car was described in our issue of March 4, 1897, together with a stock car underframe built up of structural shapes. In 1896, also, the Carnegie Steel Co. built a few 80,000-lb. flat cars and 100,000-lb. hopper cars of steel, and estimated their scrap value at $10 per ton. The hopper cars were 30 ft. long, built up of structural shapes and plates, and weighed 39,950 lbs., but it was stated that this could be reduced to 33,000 lbs. without affecting the strength.

From this time onward numerous designs for steel cars were made and a number of steel cars were built, mainly for experimental work. The whole subject was discussed in our issue of July 2, 1896, in connection with a report of a committee of the Master Car Builders' Association, which report was accompanied by plans of a number of steel cars and underframes. We then pointed out that while at that time very few cars had been built, the concensus of opinion of the best informed men engaged in rolling stock construction was that a change from wood to steel for the center sills (which structurally are the most important members of a car), was inevitable. It was also shown that steel car construction would resemble bridge work rather than boiler work, and the idea was put forward that the old reliable cast iron wheel might not prove capable of safe or economical service under 40-ton or 50-ton cars. This same idea has been presented many times since then, but improvements in manufacture enable these wheels to still be almost universally used under the severe conditions of heavily loaded cars in modern service, and with assurance of both safety and economy.

After some seven years of experimental and missionary work the steel car came rather suddenly into practical use. The new Schoen pressed steel car works were opened in 1897, and in that year 500 cars were built. By the end of 1901 there had been 46,000 cars built, and at the present time about 100,000 are in use. In 1897, the Pittsburg, Bessemer & Lake Erie R. R. ordered 600 50-ton pressed steel cars, and the Pennsylvania R. R. ordered 1,000 similar cars, but with a capacity for 55 tons of ore or 52 tons of coal. These two large initial orders afforded a striking illustration of the fact that the steel car was regarded as having passed the experimental stage and being an accepted type of railway rolling stock. These cars were expected to show that steel cars could be built as cheaply as well designed wooden cars (on the basis of cost per ton of capacity), and would result in a great saving in maintenance expenses as well as a reduction in dead weight for cars of large capacity. In commenting upon this in our issue of April 21, 1897, it was remarked that while the competition of the steel car with the wooden car would probably not be apparent for some time, yet that the increasing cost of timber and the decreasing cost of steel construction made it very certain that this competition would eventually come.

In 1899 the Bessemer & Lake Erie Ry. had 1,000 of these pressed steel cars, and at the end of 1902 the Pensylvania R. R. had about 10,000 steel hopper-bottom coal cars of 50 tons capacity, most of which were equipped with the Westinghouse friction buffing and draft gear. In 1902 the Baltimore & Ohio Ry. adopted 50-ton steel hopper-bottom coal cars and 40-ton steel gondolas as standards, and decided to build no more wooden coal cars. This road has now some 16,000 steel cars in service. The Chicago & Alton Ry. has a standard steel underframe for box, stock and refrigerator cars, and a number of other railways have large numbers of steel cars of various types and are continually adding them to their equipment.

The manufacture of steel cars is now an important industry. Pressed steel cars were first built in 1897 and cars of structural steel began to be built about 1900. While the use of steel cars is very extensive, it is confined very largely to the eastern trunk lines and a few of the smaller western lines, very few of the western trunk lines having introduced any large numbers of the cars. This is partly on account of the first cost and partly on account of a desire to wait and see actual results in cost of repairs and maintenance. It is to be noted also that a number of steel cars have been built in this country for railways in Europe, Australia, India, Africa, etc.

While structural shapes present many advantages in construction for car framing and while a number of steel cars have been built of this material, yet by far the greatest development has been in the cars built up of plates and pressed steel shapes. In fact the cars of this type far outnumber all other types of steel cars now in service. One reason for this is said to be that with pressed steel the weight and form can be better proportioned to suit the requirements, thus enabling a pressed steel car to be built of lighter weight than and equal strength with a structural steel car of similar capacity.

STEEL CARS AND THE MASTER CAR BUILDERS' ASSOCIATION.

In view of the great development in the use of steel freight cars and of the important relation which the Master Car Builders' Association holds to the rolling stock and equipment department of the railways, it will be of interest to summarize the action of this Association in regard to the steel car question.

At the annual convention of 1890, a committee on steel plate and malleable iron in car construction made a report, referring mainly to various pressed steel parts (center plates, stake pockets, etc.), but mentioning the Fox pressed steel truck and stating that Mr. Schoen, of the Schoen Mfg. Co., had designed a 60,000-lb. steel gondola car weighing 18,000 lbs. There was practically no discussion of the report, and the committee was continued, although there was some slight opposition to this. The conclusions of the committee's report contained the following suggestions:

The price of iron and steel beams, channels and plates is now low enough to make it possible to construct a flat, box or coal car of greater strength and durability and equal weight, at a cost very little in excess of a wooden car. The use of pressed steel makes it possible to construct steel cars with few parts and with shapes or forms especially adapted for car construction, of a material possessing the greatest strength for a given weight. For these reasons we believe that the extensive use of malleable iron and steel in the details of wooden cars will result in the gradual disappearance of wood, and we expect in a few years that iron and steel underframes and plate steel trucks will be generally introduced.

In 1891 the same committee again reported. It dealt with metal parts, but remarked that pressed steel freight car trucks were in service on a number of roads, and that "a shop near Chicago is engaged in building steel freight cars, and will soon have 25 or 30 cars in service." In 1892, there was no report on steel cars, but the Committee on Frieght Car Trucks presented a brief report on metal trucks, and in 1893 this committee reported that much new equipment was being provided with iron and steel trucks. In the report of 1894, metal trucks and bolsters were also mentioned.

In 1893 the Committee on Steel Center Sills for Freight Cars reported that experience with metal center sills and underframes was quite limited, being confined to the following: metal underframes for tenders, several metal underframes on the New York Central Ry. and the Lake Shore & Michigan Southern Ry., 60 Harvey steel cars of the first type on the Chicago, Milwaukee & St. Paul Ry., several Harvey cars recently built to the improved designs of Mr. McIlwain, and various special cars for unusual freight. The Michigan Central R. R. had also proposed a metal underframe of its own design, and several designs had been made by the Fox Pressed Steel Co. for cars for the Illinois Steel Co. In regard to tender frames, the report stated that they were objected to, not on account of the cost of repairs, but of the time consumed in repairs, as it affected the service of locomotives; few extra tenders were kept, and the engines had to be taken out of service while their tenders were being repaired.

As steel frames for tenders are stronger than wooden ones, and by their increased strength and durability have reduced repairs, there are some who believe them to be more desirable than wooden frames. One marked advantage has been found in the freedom from decay.

Nothing has resulted from the experience of those using the above cars that leads to a strong conviction for or against the use of steel center sills. It has, however, been found on the Lake Shore & Michigan Southern Ry. that running repairs are much less with the steel underframes.

The advantages that may be expected from the use of metal center sills lie almost solely in the increased durability and the reduced cost of inspection. As the center sills and draft rigging attachment are the parts of the car body which require the most attention from car inspectors, and cost more to maintain than other parts, it might be expected that the introduction of steel center sills would

reduce the cost of running repairs. In case of wrecks, it is a question whether the steel center sills would not be more expensive to replace than wooden sills, but the total cost of repairs to center sills and draft rigging caused by the class of wrecks which would seriously damage a steel center sill is not very large. Although the use of a steel sill might materially increase the cost of repairing center sills after bad wrecks, yet (as bad wrecks are not numerous on a well-appointed road) the result would not be an increase in the total cost of all repairs. In fact, the greater durability of a suitable steel center sill ought to so reduce running repairs as to give a decrease in the total cost of all repairs to car bodies.

A considerable number of cars have been built with iron pipe underframes, but these are scarcely practicable and are not of a type that would ever be generally used, and have therefore been omitted from this report.

The following are some of the essential feaures of metal underframe construction: 1, All joints should have sufficient area, and rivets and bolts sufficient in size and number to prevent movement of the parts one upon the other when the cars are in service; 2, all joints should be so designed as to permit repairs to be made with the least possible delay and manipulation, and if possible, without heating; 3, as far as possible the center sills should be continuous from end to end of the car.

The report referred to the general use of metal underframes on foreign railways, and was accompanied by drawings of American and foreign steel cars and underframes. The only feature of the discussion was an expression of opinion in favor of the use of rivets instead of bolts for the connections.

At the conventions of 1894 and 1895, steel cars were not considered, but in the latter year a committee on "Metal Underframing for Freight Cars" was appointed. This committee made a brief report in 1896, devoting most of its space to recommending uniform dimensions for a 60,000-lb. box car, which were later adopted as "recommended practice." In 1903, however, these were abandoned, as conflicting with the standard dimensions adopted by the American Railway Association. Several designs for steel underframes accompanied the report. Steel trucks and protective paint for these trucks were also discussed. The committee's report of 1897, called attention to the fact that with the gradual and steady increase in the carrying capacity of freight cars and the hauling power of locomotives, the insufficiency of the earlier methods of car construction "developed from wagon building and consisting of timber framing held together by nails, spikes, straps, lag-screws and bolts," was becoming more and more apparent. The committee evidently anticipated a development of steel underframes built of rolled structural shapes, as shown by the following recommendation, but as a matter of fact, pressed steel shapes have been much more extensively used:

> It is particularly desirable that even if the details of the fastenings and less important parts be left to the choice of the builder, the length, section and weight of the main sills, end sills, draw gear and bolster should be shown on the Association's drawings. Then the rolling mills and car builders who wish to take up the manufacture of steel frames for 60,000-lb. cars can take advantage of market fluctuations to buy stock when prices are low, with the assurance that the size and length of sills will surely be used by any railway companies ordering freight cars with steel frames. Further, the stock of sills carried by railways for their own use can also be depended upon to suit any steel-frame interchange freight cars that may be damaged on their lines.

In 1898, the Committee on Steel Car Framing reported that only a small proportion of the members knew anything about the matter, and that it was impossible to make any definite recommendation. A series of questions was sent out, and a summary of the answers given showed great diversity of opinion among the few members who replied. Plans of several designs of cars and underframes accompanied the report, which (with the plans presented in 1897) were thought to represent the status of the steel car at that time. The committee reported, however, that it did not believe it possible at that time to design a steel car frame which would meet with universal favor; and that the extremely limited experience with steel cars was sufficient reason for recommending the postponement of the selection of a design.

At the meeting of 1899, there was no consideration of steel cars and trucks. At the meeting of 1900, in a discussion on repairs of pressed steel trucks, it was suggested that such repairs could not be made on some roads, and that the trucks should be returned to the maker or owner for repairs. This, however, was strongly combated, on the ground that the use of steel cars and trucks was so well established and increasing so rapidly that railways should provide for the necessary repairs, and that it would involve serious delay and trouble to return the cars. At the meeting of 1901, the subject was again omitted.

In 1902, there were two discussions on the subject; one on metal center sills in wooden cars, the other on the maintenance of steel cars. In the former discussion, the advantages of steel were admitted, but several speakers objected to this combination of steel and wood, some on account of the fact that the greater deflection of the wooden sills would eventually throw too heavy a proportion of the load on the steel sills, and others because it is impracticable to successfully join wood and steel members. In the latter discussion, following the announcement that the committee had no report to present, it was shown that the 70,000 steel cars in use represented a very small proportion of the total freight car equipment; also that repairs to steel cars were being successfully made by the regular repair gangs, although roads were backward in supplying the special facilities desirable for this class of work.

In 1903 there was a topical discussion on "The Steel Car," which brought out considerable information as to actual experience, in regard to repair work especially. At the same meeting the Committee on Tank Cars reported that the ordinary style of wooden frame should not be adopted for new tank cars, and several designs of steel underframes for such cars were submitted. For the convention of 1904 two committees have been appointed to deal with matters concerning steel cars: one on "The Best Preventive of Rust on Steel Cars," the other on "Prices for Repairs of Steel Cars."

ARTICLES ON STEEL CARS.

For the convenience of those who may wish at any time to investigate the history of steel cars in greater detail, we give the following list of some of our principal articles on this subject:

Pressed Steel in Car Construction	March 28, 1891
Harvey Steel Stock Car	July 11, 1891
Improvements in Freight Car Construction	Jan. 30, 1892
Progress in Steel Car Construction	May 19, 1892
The Pros and Cons of Steel Car Construction	May 19, 1892
Harvey Steel Freight Car Truck	June 16, 1892
Harvey Steel Cars	June 8, 1893
Metal Underframes for Railway Cars	Feb. 1, 1894
Tubular Frame Cars	Oct. 11, 1894
The Construction of Steel Cars	July 2, 1896
Recent Designs for Steel Cars	March 4, 1897
Wooden and Steel Cars of Large Capacity	June 16, 1898, and Jan. 19, 1899
Metal Trucks for Freight Cars (2 articles)	Sept. 15, 1898
60-Ton Steel Hopper Car: P., B. & L. E. Ry.	Jan. 19, 1899
Steel Cars in Wrecks	May 25, 1899
Steel Freight Cars for China	Sept. 7, 1899
60-Ton Wooden Cars; Southern Pacific Ry.	July 19, 1900
Steel Framing for Box Cars	March 28, 1901
Steel Framing for Freight Cars	April 18 and May 9, 1901
Wrecks of Steel Cars	Sept. 26, 1901
Experimental Steel Cars: A. T. & S. F. Ry.	May 16, 1901; March 20, 1902
50-Ton Steel Coal Car (Vanderbilt Type); W. Va. C. & P. Ry. (with comparison of several cars)	June 19, 1902
50-Ton Steel Coal Car; Pennsylvania Lines (with friction draft gear)	Sept. 4, 1902
Tank Car with Steel Truss Frames	Dec. 11, 1902
Steel and Wooden Gondola Cars; C. & A. Ry.	Feb. 26, 1903
Steel and Composite Gondola Cars; C. B. & Q. Ry.	Nov. 12, 1903
Steel Trucks for Freight Cars	March 1, 1890; June 25, 1896; Sept. 15, 1898; June 21, 1900; May 9, 1901; June 20, 1901; Sept 4, 1902; Feb. 26, 1903.

PIVOT PIER CAISSON AND OPERATING MACHINERY FOR A HEAVY SWING BRIDGE.

A very heavy combined railway and highway bridge is soon to be built over the Missouri River at Kansas City, Mo. The structure is to contain a swing span, carrying a double-track steam railway on its lower deck and a highway with double-track electric railway on its upper deck. The span is 424 ft. long between end pins and 31 ft. wide between trusses; its total weight will aggregate 6,600,000 lbs.

For the foundation of the pivot pier of this span an unusual design of timber caisson has been used. It consists of an outer wall of wood tapering to a cutting edge on the bottom, and a filling and bracing of solid courses of timbers forming the roof of the pneumatic working chamber. These timbers do not fill the whole section of the caisson, however, but are arranged so as to form two large pockets, one on either side, which may be filled with concrete to assist in the work of sinking the caisson. The pockets are wedge-shaped, tapering down to the cutting edge, their inner wall being formed by inclined timbers which slope upward to the longitudinal solid timber backbone of the caisson. The construction is shown quite fully by Fig. 1, which gives a plan of the caisson and several half-sections taken, respectively, through the timber backbone and through the pocket for the concrete. It may be said that this design of timber caisson was first used about a dozen years ago (though not in the present perfected form) in the foundations for the Quindaro Bridge, over the Missouri River, at Kansas City, Mo. (see Eng. News, April 4, 1891). That bridge was designed by Mr. F. D. Moore, who, as Chief Engineer of the Union Depot, Bridge & Terminal Co., has also designed the bridge at present under discussion.

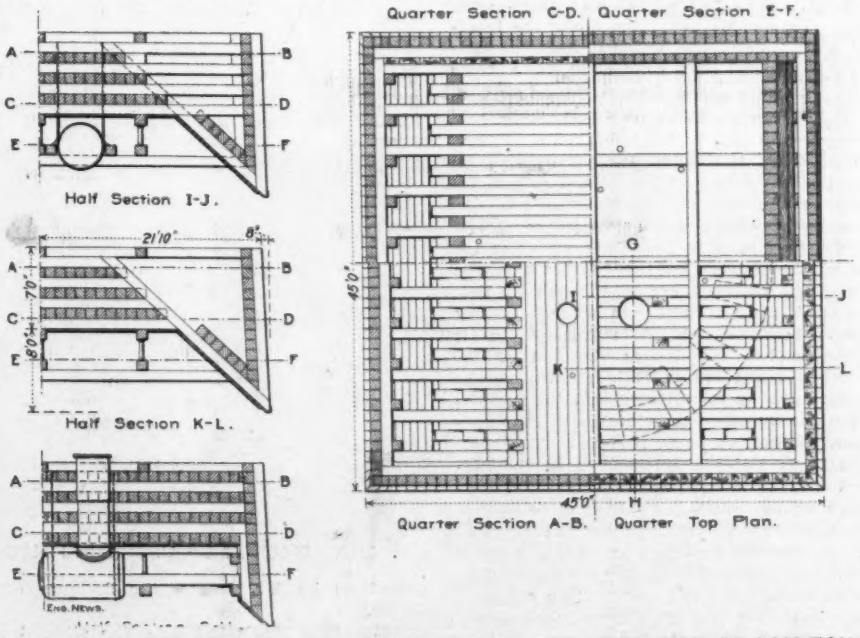


FIG. 1. PLAN AND SECTIONS OF POCKET CAISSON FOR PIVOT PIER OF 3,300-TON SWING SPAN.

OPERATING MACHINERY.

On account of the great weight of the swing span a special arrangement of the operating machinery is employed, which is shown in plan by Fig. 2. Instead of the usual four rack pinions, eight are used, grouped around the rack-circle in sets of two each; to ensure an equal distribution of

load between the eight pinions, equalizing gears are provided in the system of gearing between the motor shaft and the pinion shafts. The shafting and gearing is all located under the lower floor of the bridge, and is supplied with power by two vertical shafts extending down from the machinery house. The latter is situated at the center of the bridge, and rests on the lower chord of one of the trusses. Electric motors supply the power both for turning the bridge and for lifting and locking the ends.

By referring to Fig. 2 it will be seen that each pair of pinion shafts is connected at the top by a short bevel gear shaft, and that each two such pairs on opposite sides of the turntable is driven by a common cross shaft, which thus operates four pinions. The two cross shafts gear to an intermediate shaft, A, which is driven by bevel gear from a vertical shaft, C, extending down from the machinery house.

The equalizing gears are denoted by the letter Z. They are located at all points where a single shaft delivers power to more than one pinion. A detail sketch of such a gear is given in Fig. 3, herewith. The shaft is cut at the point where the equalizing gear is located, so that the two parts can turn with respect to each other; a bevel gear fastened to each of the cut ends meshes with a number of bevel pinions held in recesses in the driving gear. It is obvious that the arrangement is such as to take up all slack in the gearing or at the rack, so that all the rack-pinions act together. This purpose is aided, moreover, by the general disposition of the shafting between the motor drive shaft and the rack-pinions, which virtually balances the eight pinions around shaft A as a central point.

The end-lifting and locking mechanism is also shown by Fig. 2. Screw-jacks are used for lifting the ends, while the locking is effected by a vertical latch-pin on the bridge entering a recess in the abutment, the pin being moved up or down by a screw. Both locking-pin and screw-jacks are driven by a shaft extending along the longitudinal center line of the bridge to near the middle, where a bevel-gear connection to a cross shaft, B, transmits power from a second vertical shaft, D, extending down from the machinery house.

A floor-plan of the machinery house is shown in Fig. 2, slightly shifted from its true position for the sake of clearness. Two motors are provided, each of 140 HP., at 500 revs. per min., normal speed; they may be geared to either of the vertical shafts C or D, by the friction clutches, E and F. The clutches are interlocked so that only one of them can be in gear at any one time. When clutch F is thrown in it opens the latches and lowers the end of the bridge, while when clutch E is thrown in the bridge is swung open. Closing and locking the bridge is done by using the clutches in the opposite order, the motors being reversed. The position of latches and jacks is shown in the machinery house by a mechanically operated tell-tale, and a similar appliance indicates the motion of the bridge in swinging. To check the swing of the bridge when nearly open or shut a friction brake, G, is provided which may be clamped to the shaft after the driving clutch, E, is released.

As already noted, the machinery house is set directly on the lower chord of one truss. It projects outside the truss by the allowed clearance, giving a floor space 6 ft. 4 ins. wide. The house is two-storied, the motors and gearing being set on the lower floor, while the controller for the motors, the operating levers for clutches E and F and brake G, and the tell-tales, are in the second story, which is 6 ft. 2 ins. above the first.

Both the end-lifting and the turning may be done by hand, by means of special gear connections connecting (Fig. 2) to lever sockets in the bridge floor. Two such sockets are provided for turning and two for lifting. When the bridge is to be turned by hand, the power shafting is disconnected from the rack-pinions by throwing out a friction clutch on the bevel gear shaft connecting each pair of pinion shafts. The operating levers for these clutches are on the lower floor of the bridge.

MACHINERY CALCULATIONS.

The preceding description of the operating machinery for this bridge may well be supplemented by a summary of the formulas used in calculating the machinery; this summary, as well as the material for our illustrations and text, has been furnished us by Mr. Moore, the designer of the bridge.

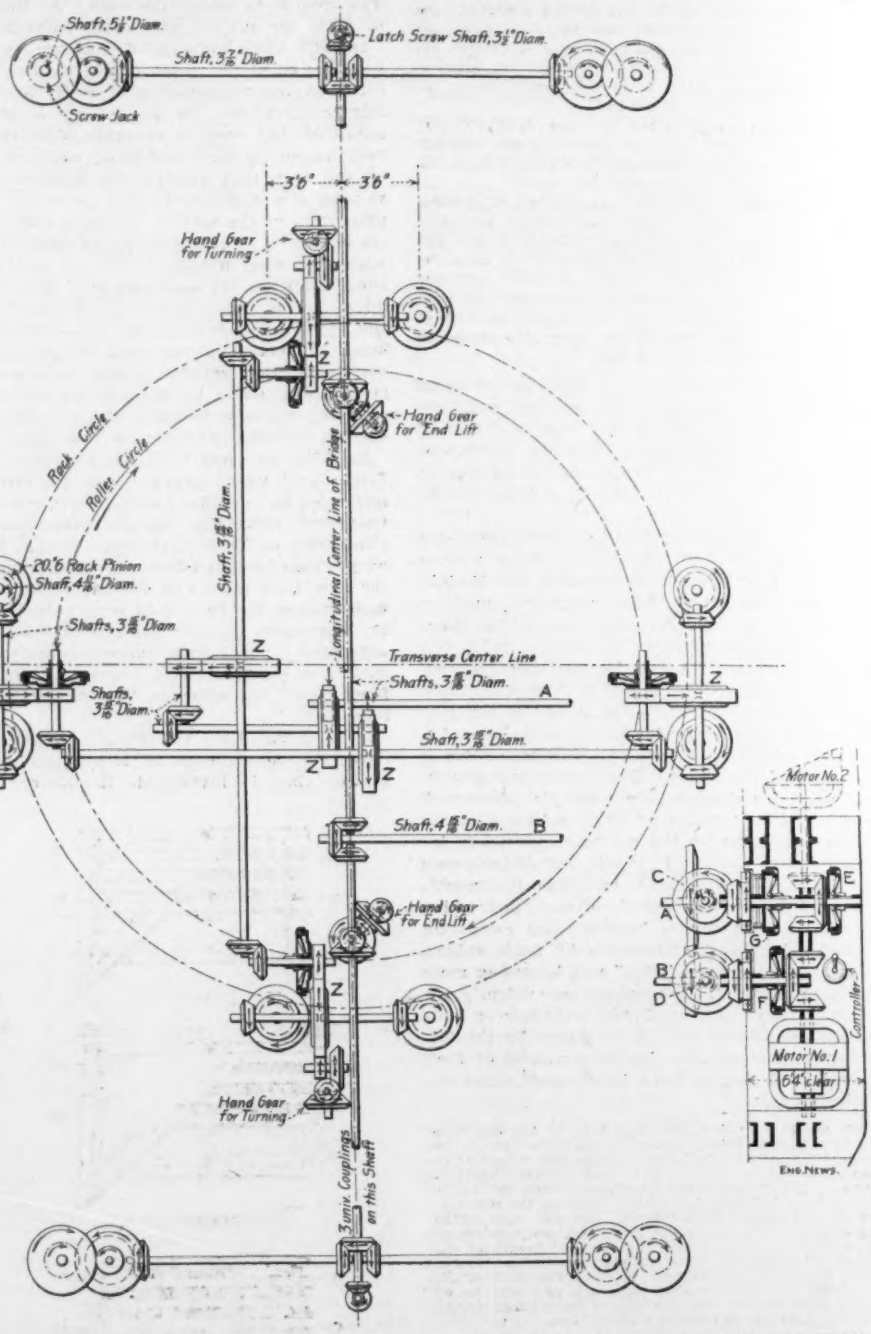


FIG. 2. DIAGRAM OF OPERATING MACHINERY FOR 3,300-TON DOUBLE-DECK SWING SPAN.

SWINGING MACHINERY.—The allowed pressure on steel rollers in pounds per lineal inch, is

$$q = 900 \sqrt{d}$$

where d is the diameter of roller in inches. The rolling friction P of a roller whose radius is ½ d = r, under a total load Q, is,

$$P = \frac{Q}{55\ r}.$$

The maximum linear velocity v_1 at the rack-circle equals twice the uniform velocity; if R_1 is the diameter of the rack-circle, it is

$$v_1 = \frac{\pi\ R_1}{t},$$

where t is the time of swinging. The time t_1 during which the motion is accelerated is one-half the total time of swinging. From this the acceleration at the rack-circle is

$$a = \frac{v_1}{t_1} = \frac{2\pi\ R_1}{t^2}.$$

Now, the moment of inertia of the bridge around its pivot is the sum of the moments of inertia of the diameter, etc., and of the superstructure. Letting,

I' = total moment of inertia around pivot,
I_1 = moment of inertia of drum, etc., around pivot,
W = weight concentrated, at any panel point,
I = moment of inertia of weight at each panel point around that panel point,
d = distance of any panel point from pivot,
R_1 = radius of rack circle;

then

$$I' = \Sigma \left[I + \frac{W\ d^2}{g} \right] + I_1,$$

and the equivalent mass at the rack-circle is

$$M = \frac{I'}{R_1^2},$$

from which the required accelerating force at the rack-circle is found to be

$$F_1 = Ma = \frac{I'}{R_1^2} \times \frac{v_1}{t_1}.$$

The force at the rack-circle must also include

the roller friction and the collar friction of the rollers. The former is

$$F_2 = P \frac{R}{R_1},$$

while the collar friction is

$$F_3 = 0.03 \frac{Qr}{R},$$

in which R is the diameter of the roller circle. Then the normal force required at the pitch line of each one of n pinions is

$$F = (F_1 + F_2 + F_3) \frac{1}{n}.$$

In case there is an unbalanced wind pressure of w per panel on one arm of the bridge, an additional force of

$$F_4 = \Sigma \frac{w\,d}{R_1}$$

is required at the rack-circle.

The friction of the shafts and gearing is figured at 12½% in gear wheels and 8⅓% on bearings. This amounts to 450% at the motor. The total force required at the rack-circle must therefore be increased by this amount and divided by the multiplication of the gearing to give the turning force required at the motor.

SCREW JACKS.—If we let

Q_1 = reaction due to end lift,
W_a = end panel point weight, including weight of jack,
α = angle of screw thread in jack,
ρ = angle of friction of screw (3° 26′).

then the force P_1 required at the pitch circle of the screw is

$$P_1 = (Q_1 + W_a) \tan(\alpha + \rho) + f + f_1 + f_2.$$

The values f, f_1, and f_2 are the following: the friction due to thrust on the screw from the action of temperature moving the bed rollers is

$$f = \frac{1}{55}\left\{\left[\frac{Q_1 + W_a}{r_1}\right] + 50\%\right\} \times 2 \times 0.12.$$

The rolling friction of the conical rollers is

$$f_1 = \frac{1}{55}\left[\frac{Q_1 + W_a}{r_1}\right].$$

The friction in the bearings of the screw shaft is

$$f_2 = \frac{1}{10}\left[\frac{P_1 r_3}{r_2}\right]$$

in which expressions r_1 = mean radius of the conical rollers, r_2 = radius of screw, and r_3 = radius of shaft.

A RAILWAY DITCHING MACHINE.

One of the expensive and troublesome classes of work in railway maintenance of way is that of forming, clearing and enlarging the side ditches. As a rule this work is done by hand labor, either by the section gangs or by extra gangs with work trains, but this is tedious and expensive especially in wet or sticky material. In view of the saving in time and cost which may be effected by machine work, several ditching machines have been devised and have been used to some extent,

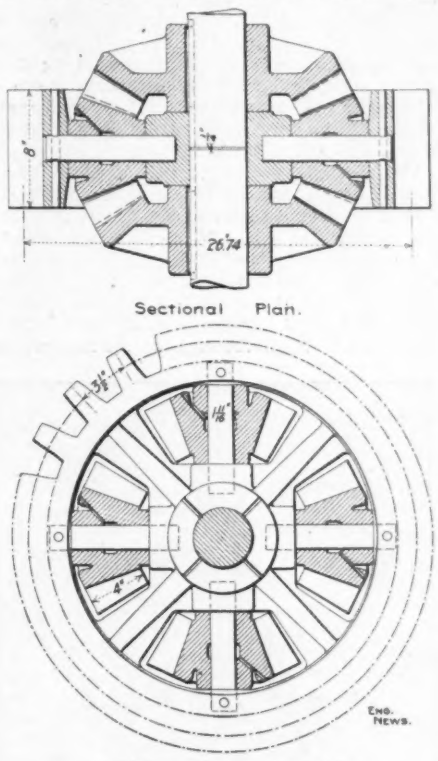


Fig. 3. Detail Sketch of Equalizing Gear.

while many railways have machines of their own design for trimming ballast slopes, shouldering banks and cutting or clearing ditches. Most of these machines are of the scraper or mold-board type, the adjustable scraper projecting from a heavily weighted flat car, and sometimes being fitted with a plow. These machines simply remove the earth and throw it aside, and are therefore of limited service in cuttings.

The ditching machine which is shown in the accompanying cuts is of the dipper or shovel type, as distinguished from the scraper type, and its special feature is that it loads the earth upon cars for removal. It is operated in connection with a work train equipped with a hoisting engine or "rapid unloader" on the front car. The machine consists of a frame mounted on the car, and so arranged as to be hauled along the train as the cars are loaded. The front of the frame is low, and has pivoted to it a dipper handle reaching towards the rear and supported near its free end by a curved guide rail attached to the higher part of the frame and extending out to the line of the ditch. The dipper arm and guide rail are placed on whichever side of the car the ditch is to be cut. A cable attached to the end of the dipper arm is led to a sheave on the top of the frame and then down to the foot of the frame and along the train to a drum on the hoisting engine. On the end of the arm is a dipper or scoop bucket of 1 or 1½ cu. yds. capacity, with a dumping bottom.

The length of the dipper arm is 26 ft., and the height from rail to top of curved guide rail is 8½ ft. The reach of the bucket from the track can be varied 4 or 5 ft., as the lower end of the curved guide rail is adjustable as to distance from the car, so that the ditch can be cut from 5½ ft. to 10 ft. from the nearest rail. A mold board or scraper can be attached to the dipper arm, immediately in front of the dipper, for use in trimming slopes and shouldering banks.

In starting work, the device is mounted on the rear car of a ditching train. The dipper handle is swung down and out, putting the bucket in position for the ditch, as in Fig. 1. The train then moves ahead until the bucket is filled, when it is stopped; the dipper arm is then hauled up until the bucket is over the car, when the door is released, dumping the contents upon the car, as in Fig. 2. The arm is then again allowed to run down in position for another cut. As the car is loaded the frame is hauled ahead along the train by a chain attached to the plow cable leading to the hoisting engine on the front car.

The first machine was put in service last season on the Baltimore & Ohio Southwestern Ry., and with four men and a train crew is said to have done the work of at least 100 laborers. As now improved, only three men are required: one to operate the hoisting engine or rapid unloader, one to release the latch for dumping the bucket, and one to couple up the cable for moving the machine ahead. It is further said that the machine will excavate and load from 45 to 60 cu. yds. per hour, and that it is well adapted for handling soft and sticky material that cannot well be loaded by hand. It is the invention of Mr. D. H. Mahoney, Supervisor of the Baltimore & Ohio Southwestern Ry., at Vincennes, Ind., and the Railroad Ditching Machine Co., of Vincennes, has recently been incorporated to arrange for its manufacture.

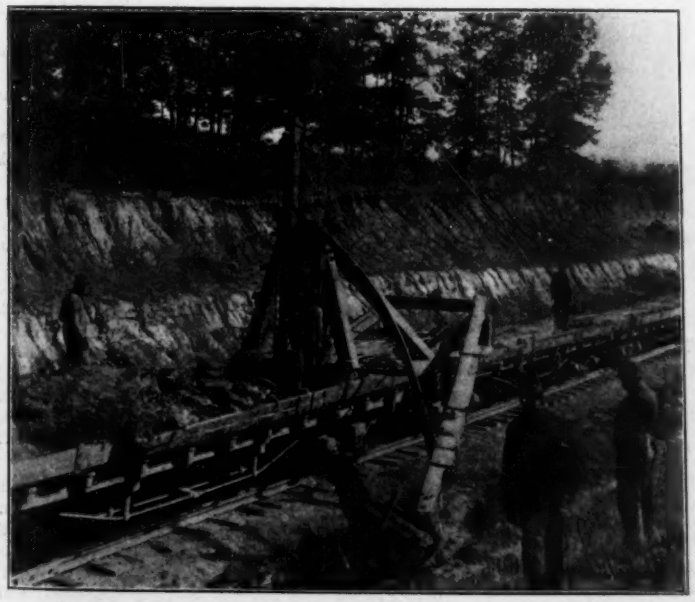


FIG. 1. RAILWAY DITCHING MACHINE (IN POSITION FOR TAKING A CUT).

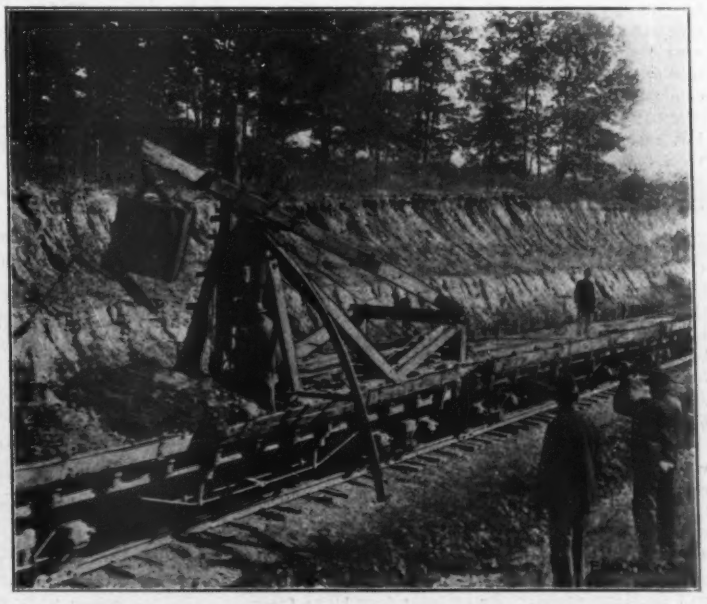


FIG. 2. RAILWAY DITCHING MACHINE (DUMPING THE BUCKET).

D. H. Mahoney, Supervisor, Baltimore & Ohio Southwestern Railway, Vincennes, Ind., Inventor.

ARGENTINE RIVERS.

By E. L. Corthell,* M. Am. Soc. C. E.

The three rivers under consideration in this article form together—for there is really only one

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—the second largest river system in the world. The rapid development of Argentine and the increase of its commerce, both exterior and interior, give capital importance to these rivers, which are truly the arteries of that great Republic. As questions of improvement of these waterways have been under examination and study and the methods have been generally decided upon by the Ministry of Public Works and its engineers, it is proper to state in some detail the hydraulic features.

The extension of the drainage area, or watershed, of the La Plata and its tributaries, is over 1,200,000 square miles. The alluvial plains cover nearly 500,000 square miles. They are about 1,200 miles long, and over 400 miles wide, composed of a rich soil. They possess a climate that has the range of that of the Mississippi Valley, except that snow, ice and even frost are exceedingly rare, and its equability cannot be surpassed. An idea what those plains are can be gathered from the following sentence by Mr. Herbert Gibson, who owns extensive sheep ranches in Argentine.

It would be possible between the longitude of Buenos Aires and San Luis and the 33d and 37th parallels to have a wheat field with furrows 300 miles long and the headlands 200 miles wide, with no further incident to break its monotony than an occasional narrow streamlet and here and there the cluster of one-storied houses forming the local townships.

The agricultural and pastoral products of Argentine are invading the markets of the world, and its animal products are soon to enter the United States market; its commerce is increasing and becoming more and more important, as a competitor with other countries and as a factor in supplying the food wants of mankind.

There is but one port of any importance outside of the La Plata system, and nearly all of the 26,000,000 registered tons of entrance and clearances of the year 1902 were at the ports of the River Plata and its tributaries. A word should be said about the imports and exports before taking up the hydraulic features, for, after all, the study of a river is for the purpose of seeing what its condition is, or can be made to be, in reference to transportation.

The area of Argentine is 729,000,000 acres, 200,000,000 of which is arable land and 250,000,000 pastoral, the remainder being woodland, rivers, mountains, lakes, arid regions, etc., etc. The cultivated area has increased as follows: In 1891 it was 7½ million acres; 1901, 18 million; 1903, 20 million. If we compare its increase with some other countries we have the following on the basis of unity in 1860. 1880, United States, 1.8; Canada, 1.3; Egypt, 1.3; Brazil, 2.0; Australia, 3.3; Argentine, 3.5. 1900, United States, 4.4; Canada, 3.7; Egypt, 1.5; Brazil, 3.0; Australia, 12.2; Argentine, 16.8.

In millions of hectoliters its wheat crop increased between 1888 and 1900 from 8 to 36.7 (22,000,000 bushels to 100,000,000).

The wool crop of Argentine is one-fourth of that of the whole world, and the exports have increased from 214,990,189 lbs. in 1880 to 522,735,932 in 1900. In the same period its imports have increased in value from $45,535,880 gold to $113,485,069, and its exports from $58,380,787 to $154,600,412.

One of the most important exports, and one which is rapidly increasing, is frozen and chilled meat; frozen beef exports having increased in the last four years from less than 6,000 tons to more than 70,000 tons, and, while this development is due partly to the closure of English and French ports to live Argentine cattle, the development will continue rapidly, for at least four large freezing establishments are now under construction, there having been but three previously. One of the four is being built solely for the purpose of exporting chilled meats and by-products to New York city, the contracts for delivery being already made.

With these fragmentary and very brief statements of the commercial situation it is in order to describe the channels of commerce. First, however, it should be stated that the delivery of products to the seaports is not dependent upon fluvial transportation, for the railways carry a large part of the production for export and of import. There is a complete network of railways radiating from Buenos Aires on the River Plate and Rosario on the Paraná. In 1880 there were only 1,560 miles in operation; in 1903 there are about 11,181, with important extensions now being made to nearly all lines and new projects in hand.

The mileage of Argentine railways appears very small in comparison with that of United States railways, but, due to the much smaller population (there are only 5,000,000 inhabitants), the length of line per 1,000 inhabitants is 2.1 miles as against about 3 miles in the United States, 0.57 in Germany, and 1.05 miles in France.

The accompanying map, Fig. 1, which was an exhibit of the writer's report to the Minister of Public Works upon the rivers to the north of Martin Garcia, this being the name of the island at the head of the River Plate, will show the principal part of the navigable portion of the rivers and that part of the railway systems lying between them, and in what is called "Mesopotamia Argentina." While the scale on the map will enable the reader himself to ascertain the distances, the following table, in which they are reduced to English geographical miles, will aid him in his examination.

Fig. 1. The River Navigation System of Argentine.
(Scale: 1 in. equals about 140 miles.)

Distances on the Paraná River.

	Miles.
Buenos to San Pedro, head of the delta	145
" " Rosario, principal river port	224
" " Paraná, Sta Fé and Colastini	324
" " Reconquista	510
" " Corrientes, below confluence of rivers	674
" " Posadas, on Alto Paraná	858
" " Asuncion, on the Paraguay	840

There is, however, a light draft navigation much further up these last two tributaries. The distance to Cuyabá on the Paraguay is over 1,850 miles from Buenos Aires, and the Alto Paraná is navigable 180 miles above Posadas, nearly to the Falls of the Yguazú, over 1,030 miles above Buenos Aires.

The Paraná River measured along its main tributary, the Paraguay, is over 3,000 miles long, extending far up into the rainy regions of Brazil and receiving the drainage of the Andean slopes.

Distances on the Uruguay River.

	Miles.
Buenos Aires to Concepcion del Uruguay	189
" " " Colon	268
" " " Concordia, head of principal navigation	280
" " " Monte Caseros, terminus of Argentine N. Eastern Railway	360
" " " St. Tomé (Arg. N. Eastn. Ry.)	523

It is, however, navigable at high water 300 to 400 miles further. It rises on the far distant coast range of Brazil, near the Atlantic Ocean.

All these rivers have been as completely surveyed and investigated as the resources of the National Government will permit. The work was begun about four years ago on a systematic and adequate plan under very capable supervision and has been continued to the present time. Lines of precise levels are being run in order to connect the river gages, at least as far as Asuncion, Posadas and Santa Fé.

The accompanying map, Fig. 1, will show these lines and their extent up to the spring of 1902. During the last year the line approaching the Uruguay has reached Conception del Uruguay and is now advancing north from Villaguay towards Concordia, the extension of the Entre Rios system having been completed. They will be continued until the entire work is completed to Corrientes, Santa Tomé and Posadas, and probably to Asuncion.

This leveling is really precise and is being done by the best German instruments. On account of the difficulty of doing such work along the river banks through its thick growth of underbrush the lines are run along the railways. The results are not only useful in the hydraulic study of the rivers and particularly in ascertaining their hydraulic axes, but in furnishing absolutely reliable bench marks and references to the railways.

PARANA RIVER SURVEYS.

The fluvial regimen involves two intimately connected elements: the slope of the surface and the discharge of the river in the function of its height upon any given gage. These conditions cannot be reliably ascertained without connecting the gages by precise levels.

Above Rosario there is no tide; below that point it must be taken into consideration. However, having connected the gages by the bench marks established by the precise levels—from Buenos Aires to Reconquista—510 miles—the slope obtained, by taking the mean height of the river surface for a month on each gage and then drawing a continuous curve through these mean heights, would correspond to the mean height of the river, in which the effect of high and low tides does not figure, their action being eliminated.

Fortunately an extraordinary low water occurred on Nov. 22, 1901, 5 ins. below the zero of the local gage at Santa Fé, and, later, on completing the line of precise levels to Reconquista and with the hydraulic zero fixed, simultaneous readings were taken of the tides and river heights at numerous stations.

The object of these observations was especially to determine the propagation of the tides in the Paraná River and to calculate the effects upon the regimen of the river of the enormous masses of water alternately received and discharged. Another important and quite necessary investigation was to ascertain the amount of sediment in suspension. To ascertain this an extended series of observations was made. The character of the river bed, its geology to a depth below any possible constructions or scour, was ascertained at Rosario by a minute examination of the material procured by an extended series of borings.

It was the original intention to make a continuous detail survey of the entire river, but the necessity of ascertaining as early as possible the conditions existing at the various bars and shoals scattered along the river from the head of the delta to Paraná led to isolated surveys being made, followed by the survey of the intermediate stretches. This latter work is now in progress, the bars having been completely surveyed and the amount of material to be dredged ascertained. The basis for those calculations is a channel at low water, or zero, 21 ft. deep and 100 meters (328 ft.) wide from the delta to Rosario, 19 ft. deep to Colastiné, and 10 ft. from there to Corrientes and Asuncion on the Paraguay. The Alto Paraná is not susceptible to dredging, its obstructions being serious rocky ridges causing rapids, where there is not over 5 or 6 ft. depth at low water.

URUGUAY RIVER SURVEYS.

The basis of the proposed improvement of this river is as follows: From the mouth of the river

at Nueva Palmira to Fray Bentos in Uruguay (where Liebig's extract of beef is made), 19 ft., thence to Concepcion del Uruguay 17 ft., thence 15 ft. to Colon, thence to Concordia 9 ft. and 8 ft. over rock.

The regimen of this river is entirely different from that of the Paraná, and could be investigated on different lines. It is a great torrential river at times, and soon afterwards a lake, or at least a river with a very flat slope. Taking advantage of this feature, the general slope of the river could be established in advance of the completion of the line of precise levels.

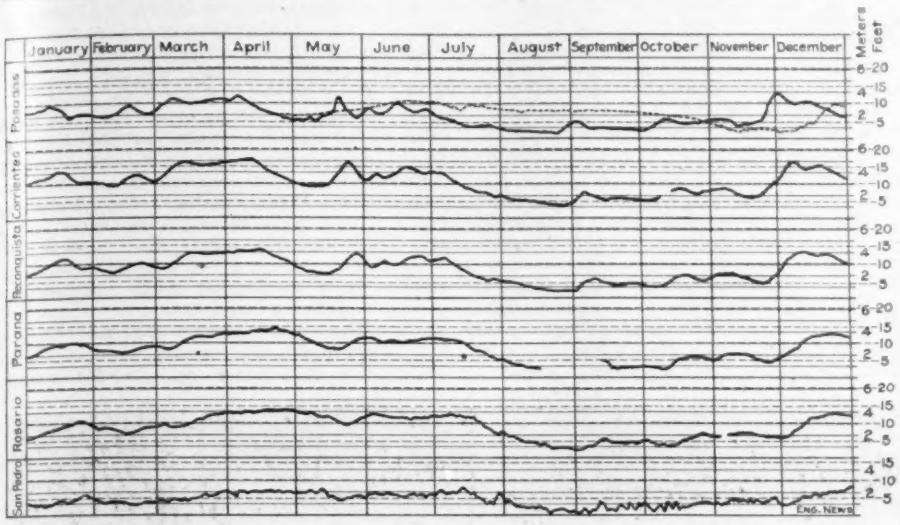


FIG. 2. PROFILES ON THE PARANA RIVER IN 1902.

Between December, 1900, and May, 1901, there occurred an extraordinary period of low water. The gage readings of the month of February were selected for the purpose, taking two points a long distance apart. On the assumption that the geometric locus of the high tides is a horizontal plane, a case admissible in a river of very small slope—there was taken, as an ordinate extending down stream, the mean of the maximum readings on the tide gages. The extremities being thus obtained, there was found the relation of the zeros of the various gages, all referred to that of Nueva Palmira, the lowest one down stream (see Fig. 1). There was also found the geometric locus of low water in the same manner. By this means the amplitude of the tide at low water was ascertained.

By a special line of levels between two of the gages the slope has been deduced, and the general slope of the entire river from Palmira to Concordia was obtained and a longitudinal profile made, and also the instantaneous profiles of maximum, ordinary and extraordinary tides at each gage station. On the longitudinal profile, with these data, the propagation of the tidal wave clearly appears. The slope at high water of the river has been carefully ascertained from the gage readings.

It may be remarked here that one important aid in the investigations on all these rivers has been not only the employment of numerous staff gages and self-recording gages (mareographs), but also the liberal use of the telegraph. There are eight mareographs from which daily telegrams are received at Buenos Aires and from ten staff gages. These cover the rivers, from Buenos to Asuncion, Posadas and Barra Concepcion, about 75 miles above Santo Tomé, on the Uruguay. The writer suggested this daily telegraph reporting in order to know what the two rivers were doing, and to predict from the plotted profiles of these daily readings the time of floods and their amplitude, as well as seasons of low waters.

As it would not be possible to post engineering assistants at all these points, the "Prefectos"—Internal Revenue officers—read all at the same hour and telegraph the daily records, etc. The utility of this work is evident, for not only does navigation greatly benefit by it, but all persons engaged in any constructions, or those who for any reason need to know the stage of the river several days in advance. The writer's experience in building bridges on the Mississippi, when he had telegraphic reports from St. Paul down, led him to suggest the same method on the Argentine rivers.

He is able to show the very interesting profiles of an entire year—1902—(see Figs. 2 and 3). Although they are on a much smaller scale than the charts in the office at Buenos Aires, from which the predictions are made, one can easily trace the movement of the crests of the floods and note the time required to reach certain points.

The Uruguay River has been admirably surveyed and investigated. Few great rivers have been more exhaustively studied, both scientifically and practically, and not too much praise can be accorded to the very capable and painstaking engineer who has had charge, in the field of the entire work—Mr. Henry—stationed at Concepcion del Uruguay.

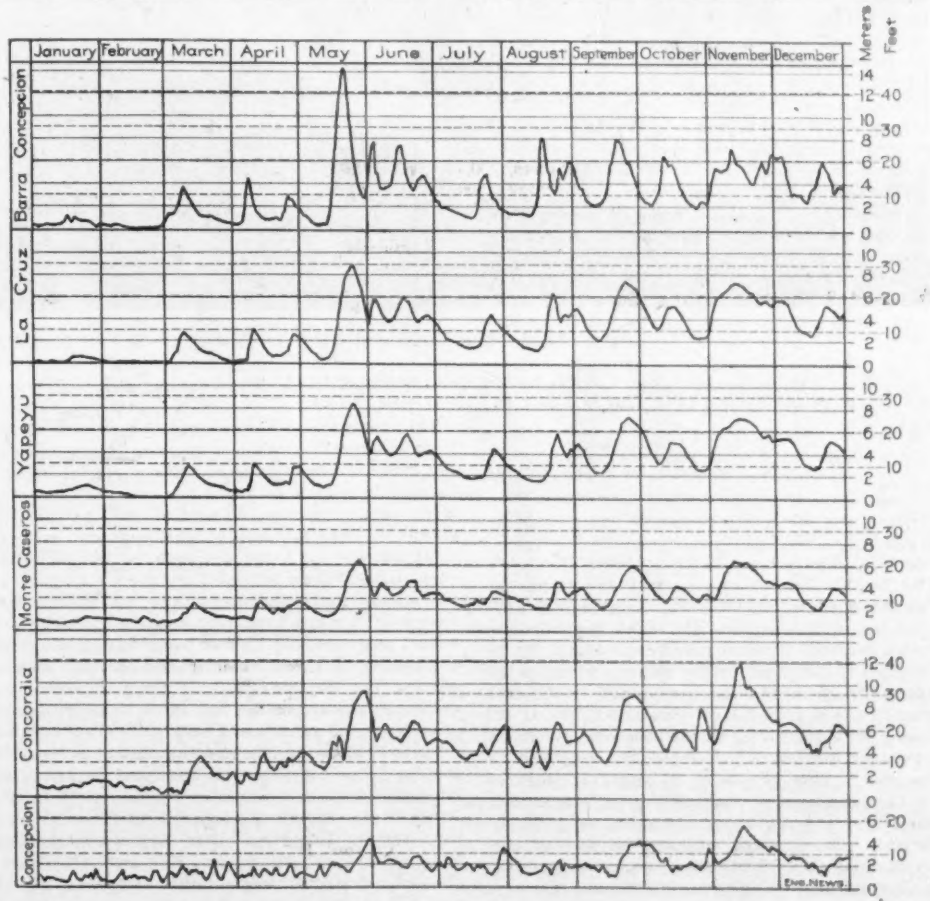


FIG. 3. PROFILES ON THE URUGUAY RIVER IN 1902.

RIO DE LA PLATA.

This great estuary is of such size and character and its hydraulic conditions are so involved that only its most salient features can be mentioned.

It has been divided for convenience into the Lower, Middle and Upper Rio de la Plata. The two former are now under very careful examination by the ministry of marine, the object being to ascertain the accurate location of channels and shoals, the depth of water available for navigation, the direction and velocity of currents and the character of the material composing the bed of the river. Two important results are anticipated, first to properly locate the light ships and luminous buoys between Buenos Aires and the ocean—nearly 150 miles—and second, to formulate the best plan of improving the great Punta Indio bar, over which there is only 19 ft. of water at low tide, though the steamers can and do plow through the meter or more of soft mud forming the upper stratum of the bed of the river. On the upper Rio de la Plata the judicious location of the luminous buoys produced a decided deepening (14½ ft. to 19 ft.) by the continual passage of deep-draft steamers through the buoyed channels. Assuming that the lightships and luminous buoys are properly located in respect to the predominating currents, it may be reasonably expected that similar results will follow in the Middle and Lower Rio de la Plata.

The upper Rio de la Plata has been exhaustively surveyed and examined geologically and hydraulically, in order to become thoroughly acquainted with the very difficult conditions existing in this extensive area of channels and banks—a river 30 miles wide, with a very limited depth, a multitude of shoals and the discharge through a dozen channels—and along a face of 40 miles, of 163 cubic miles of water per annum from the Paraná alone—bringing in suspension 68,000,000 tons of solid matter. If we consider the Uruguay also we may safely estimate an annual discharge of about 80,000,000 cubic yards of sedimentary matters. The investigations included the regimen of the tides. The study of this difficult subject is too extensive to be treated in this article.

It covered the following principal points:

(1) The relation between the mean current velocity, its superficial slope and its depth in a given vertical.

(2) The mean velocity of section in each channel and the corresponding discharge.

(3) The general direction of the waters at low water.

The study of the first subject established the mean and bottom velocities corresponding to any vertical before and after artificial deepening, or the increase of mean and bottom velocity.

From the second point has been determined the increase of discharge which the new section should have in order to maintain that section.

From the third point was ascertained the direction which the water would take in respect to the curves of the bottom, and so to decide which was the best course by which to lay out the channels to be deepened.

With the above brief summary of the general conditions existing in the three rivers under consideration and the methods of examination, some general results of the surveys and investigations may be of interest.

THE PARANA.

That part of the river which has been studied carefully is between the Delta and Santa Fé. The accompanying table shows the facts as to the absolute level of the water surface at the various points at the time of the highest flood known when the gage at Rosario read 7.25 m. (24.4 ft.) above its zero.

Location.	Absolute height above 0 at gage at Buenos Aires.	Slope.
Santa Fé	15.313	33.7
San Lorenzo	11.423	35 0
Rosario	10.376	32.3
Villa Constitucion	8.830	33.7
San Pedro	6.136	34.1
Mouth of the river	0.630	....

The heights are in meters and the slopes in millimeters per kilometer. The longitudinal profile of the water surface under such conditions shows a straight inclined plane from Santa Fé to the mouth of the river, with a velocity in the main channel of 1.45 m. (4.7 ft.) per second, and a discharge in the main river of about 1,100,000 cu. ft. per sec., saying nothing of the vast volume flowing over the low lands from 6 to 10 ft. deep and 25 miles wide. The records of 25 years at Rosario show that the river discharged annually from 405 cubic kilometers per annum to 1,558, an average of 681.44. The average annual discharge of the main channel alone in the above period was 16,108 cubic meters per second (over 565,000 cu. ft.).

Comparing the discharge of three years, 1881, '82, and '83, with that of the Mississippi River, we have the following:

Year.	Mississippi.	Paraná.
1881	780 km³	1,558
1882	562 "	900
1883	606 "	416
Total	1,948 km³	2,824
Mean	649 "	958

Some other comparisons may be of interest.

The Volga, the greatest river of Europe, has, according to Professor Timonoff, a modulus which has varied between 294 km³ in 1883 and 400 km³ in 1884.

Professor Guillemain, in his "Navigation Intérieure," Paris, 1885, gives the modulus of the Mississippi as 536 km³; the Ganges 475 km³, the St. Lawrence 315 km³, the Danube 234 km³, the Nile 182 km³, the Po 54 km³, the Rhine 35 km³, the Seine 7.87 km³. We find the Paraná in a mean of 25 years to be 681.44 km³.

In reference to sediments in suspension, a very extended and minute examination has been made covering a long period and under varying conditions, taking samples of the water at four different points from Santa Fé to Campana on the Paraná de las Palmas mouth in the delta. The average amount is about 100 grammes per cubic meter, the range at Santa Fé being between 53 and 233, at Rosario between 61 and 92, Villa Constitucion 39 and 171, Campana 42 and 179.

The Mississippi observations show a minimum of 200, a maximum of 1,800 and an annual mean of 799. The Danube, a minimum of 100, maximum of 1,100 and a mean of 283. The Po has an annual mean of 1,380. The Rhone, 870. The Ganges, a maximum of 1,493. The Brahmaputra, 3,000, and the Nile, 1,580.

This comparison shows that the waters of the Paraná contain much less sediment than those of the great rivers mentioned. The material in suspension is a dark yellow sand, and very fine, the larger grains not exceeding 0.01 mm. to 0.002 in diameter. The fineness of the sediment and its small amount no doubt accounts for the fact that very little change is found from year to year in the shoals and channels of the La Plata. The finer particles are kept in motion by the tidal and fluvial currents and by the wave action over the great area of shoal water of the estuary, slowly moving the floating mass of finely comminuted sediment forward to the sea, there to be deposited at last over its great areas and in its great depths.

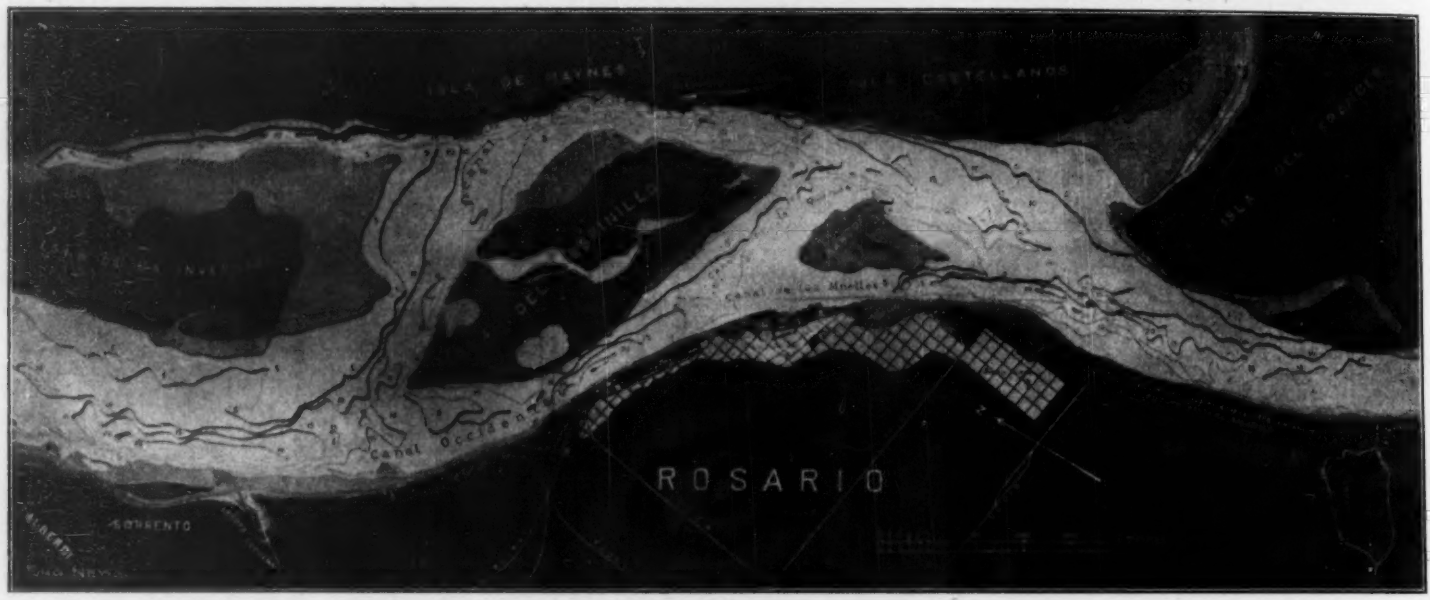
An indication at least of this action is seen in the fact that the sediment observations taken at kilometer 6 south channel at Buenos Aires in the River Plate, during the same 9 months—November, 1900, to July, 1901—that they were taken at Villa Constitucion, Santa Fé and Campana, showed a mean of 146 grammes, as against 81.114 and 102 at the above points. During this period the Uruguay was discharging into the head of the River Plate comparatively clear water, its sediment amounting to only a mean of 24 grammes per cubic meter, the range being between 11 and 59. One cause of the greater amount of sediment in suspension in the upper Rio de la Plata is the deepening of the channels there, the material moved amounting to more than 20,000,000 cu. yds. per annum. Still another and important cause is the effect of waves upon the bed of this shoal estuary and upon its extensive banks, the surfaces of which are nearly at the surface of the water.

There is one feature, however, of a different kind in the Paraná River—a formation, growth and movement of islands. The investigations made at Rosario to ascertain the physical conditions disclosed the above feature clearly. To illustrate it there is shown in Fig. 4 a photograph of the relief map of the river in front of that port.

A comparison of the charts of all the surveys, covering over 50 years, showed that the island of Espinillo had moved down stream its entire length —2½ miles— in half a century, and that it had assumed in its travels different positions. At present it is swinging across the main channel, its upper end, near the shore, causing a deep channel between it and the high bluff of the mainland and the other end, while tailing off towards the opposite bank, throwing out a shoal towards the Rosario shore, shoaling up almost completely the entrance to the port from below.

The formation and down-stream movements of islands and bars is not, however, an unprecedented phenomenon. The same result is seen on other great sedimentary rivers. In order to ascertain as nearly as possible the general history of the river, the writer got together for a comparative study over 90 ancient maps, dating from 1525 to 1885, in album form, copying and changing the scales so as to bring them into something like a uniform scale. While all the older maps are very incorrect and lacking in detail features, yet one can see as he turns over the leaves of this interesting portfolio how the river has slowly been filling its wide channel with islands and banks. At first it appears to be an estuary, extending well up towards Santa Fé and later the islands, and a contracted channelway slowly develop until the present river, with its well-defined channels and shores and its islands, comes before the eye. What the river was in still more remote ages no one can say with any certainty, but it has a history, no doubt, similar to that of the lower Mississippi. At first a wide deep estuary extending nearly to Cape Giradeau, gradually filling up by the immense deposits coming from the mountains and great plains until it reached the coast line, with its land formations, and there invaded the Gulf of Mexico to find room for its deposits, encroaching upon it more than 200 miles in the last 4,500 years. The Paraná is doing the same thing, but more leisurely, as it need not look for such a vast depositing ground, but its delta is slowly moving out into the head of the estuary and towards the sea, for while the channels in the head of the estuary are deepening, the shoals are rising and the land formation extending.

Navigation finds itself hampered below Rosario


ROSARIO
Canal Occidental
SOLEDAD
Canal de las Montes
ISLA DE HAYNES
ISLA DE CASTELLANOS
SOLEDAD
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by very few obstructions. There is practically a depth of 21 ft. everywhere to the head of the estuary. At two or three points the channel is tortuous through the shoals, but these are being buoyed by the Government. Above Rosario towards Santa Fé there are five bars, requiring the removal of a total of about 2,000,000 cu. yds., to give a channel 19 ft. deep at zero and 328 ft. wide. The changes in the bed of the Paraná are so slow that it is believed that the channel once dredged, will maitnain itself.

Above Santa Fé it is impracticable to make and maintain a channel for ocean vessels, as it would require the dredging of about 40,000,000 cu. yds. to make the channel, and an unknown but not negligible amount to maintain it. For that reason the resources of the Government compel it to limit the channel to 10 ft. depth for steamboat navigation. This will require the removal of about 5,250,000 cu. yds.

The navigation, particularly over-sea, is rapidly increasing, and for that reason it became necessary to improve the port facilities, especially at Rosario.

The registered tonnage of entrances and clearances there was 802,299 in 1881, 2,432,000 in 1803, and 3,300,000 in 1899. The coastwise tonnage in the same period increased from 600,000 to 1,245,000.

The proposed port of Rosario would require an article by itself, and mention only can be made of it here. The contract, by international competition, was let to Messrs. Hersent & Son and Schneider, of Creusot, France. It will have a continuous frontage of over two miles, provided with all the facilities required by a modern seaport. The total cost will be from $10,000,000 gold to $12,000,000. The contract comprises not only the construction of the port, but its operation for 40 years.

The commerce at present is largely the export of the products of the country, brought to Rosario mostly by the railways. It is expected that, with the provision of better facilities, it will become also an important importing point. In cargo tonnage it is now quite a respectable port, this having increased from about 200,000 in 1881 to nearly 2,000,000 in 1899. As far up as Colastiné we find a port with a cargo tonnage of some 600,000 per annum.

Some features of the Uruguay River are of interest, as disclosed by the examinations and surveys.

At low water this is practically a tidal river, the tides, sometimes, under the action of winds from the 2d and 3d quadrant, reaching Concordia, 280 miles above Buenos Aires, with an amplitude of a meter.

The bed of the river is generally composed of sand, but in the lower reaches mud predominates. At many points on the upper reaches of the Lower Uruguay gravel appears, being from one to two inches in diameter.

Above Concepcion del Uruguay, which, for convenience, separates the Lower from the Middle Uruguay, ridges of gravel and solid ledges of rock appear. Below this port is ocean navigation, above it steamboat navigation only, except that the smaler ocean vessels, steam and sail, reach Colon and the important Uruguayan port of Paysandú, nearly opposite.

The various passes requiring dredging to reach Concordia with the normal depth are shown on Fig. 1, and they have all been as carefully surveyed as the San Francisco Pass above referred to. It is the intention of the Government to make, maintain and buoy all these channels, so that navigation can be carried on day and night.

The third division, the Upper Uruguay, is composed of a series of rocky ridges with pools between. During high water there is a considerable navigation carried on by some very comfortable steamboats belonging to the Argentine Eastern Ry.

During ten months of the year there is generally sufficient water for boats drawing a meter. The extreme fluctuations of depth can be seen from the remarkable difference between the low-water discharge and the high-water discharge, the former being less than 30,000 cu. ft. per second, and the latter more than 560,000.

The Rio de la Plata can only be briefly touched upon in describing the results of the surveys and investigations.

The configuration of the shores, the banks and channels, as well as the immediate delta of the Paraná and the mouth of the Uruguay, can be seen on Fig. 5. On it can also be seen the situation of the Port of Buenos Aires and its channels to the anchorage, where there is deep water, the route of navigation to the upper rivers and the positions of the fine system of luminous buoys, that make these channels as easily navigated by night as by day.

In the head of the estuary is seen the rocky island of Martin Garcia, which stands in the center of the deep channel coming out from the Paraná and Uruguay. Above this division into two channels there is a single deep channel, in places nearly 100 ft., with a minimum width of about one mile. This fine channel continues uninterrupted to the head of the estuary at Punta Gorda, receiving in its course the waters of the Paraná, Guazú and Bravo, and other affluents forming this part of the Paraná delta.

The two channels of the Paraná used by ocean vessels are the Guazú and Bravo. The Paraná de las Palmas is a splendid deep river, but the bars at its mouth close it against the entrance there of ocean vessels. They ascend the main river to the

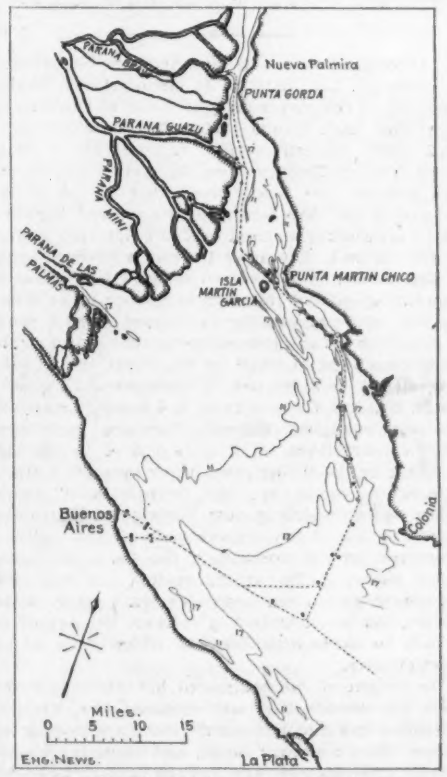

Fig. 5. Map of the Rio De La Plata.

head of Las Palmas and then come down to Zarate and Campana, where there are important meat-freezing establishments. A project is on foot for cutting a channel between the two rivers, from above Zarate.

Passing seaward of the line on Fig. 5, drawn between Colonia and la Plata, we enter the middle division of the Rio de la Plata. Almost immediately begins the great Ortiz Bank, which extends nearly the entire distance to Montevideo. This bank is the cause of the deep channel near the Argentine shore, extending seaward, interrupted, however, by some lateral and isolated banks and the great Punta Indio Bank above mentioned.

The following quotations are from a communication presented to the Düsseldorf International Navigation Congress last year by Mr. Fernando Segovia and the writer, delegates of the Argentine Government to the Congress. The former is the Chief of the Department of Surveys of the Ministry of Public Works:

> These are the general features of the Rio de la Plata. A most careful detailed survey has been made of the entire area of the upper division by the Ministry of Public Works. The exact relations of the coasts have been determined by careful triangulation, and the soundings located with exactness in accordance with the triangulations. The charts made from the surveys will serve as the basis for the comparisons that may be required in the future in order to follow the changes that may take place in banks and channels.
>
> The bed of the estuary has also been carefully investigated by a large number of borings and by an analysis of the material.
>
> Generally speaking, the bed of the upper Rio de la Plata is composed of the following materials:
>
> (1) A stratum of fine sand mixed with clay. (2) A stratum of yellowish grey clay. (3) A stratum of dark clay with sea shells. (4) Near the coast green "tosca" (loess), changing to pink. (5) Tertiary subpampean sand.
>
> While studying the geological conditions there was also studied the interesting question of the process of deposits of sedimentary matters; and numerous and extended examinations were made of the waters of the river, taken at different points, and at different depths and under varying conditions, filtering the water carefully and measuring by powerful microscopes the grains of sand and particles of other materials. These observations taken in connection with the study of velocities, the tidal movements and other hydrographic studies made it possible to calculate the amount of excavation going on annually in the upper part of the estuary in the vicinity of Martin Garcia mentioned above. The average deepening in those channels has been found to be about 1 in. to 1.4 ins. per annum, and this represents a volume of from 19.5 to 26 million cubic yards—the same results as are found at the deltas of all great sediment-bearing rivers.

The subject in hand in this article is one of great engineering interest to hydraulic engineers, but a volume, not a few pages is necessary to set forth in consecutive and systematic order and in complete form the details of the various features so carefully examined and studied. The surveys and examinations in the upper Rio de la Plata alone during fifteen months (July, 1900, to October, 1901) cost about $120,000 gold. This will give an idea of the extension and completeness of the work.

This work, as well as that on the other rivers, was under the supervision and constant attention of the late Inspector-General of Hydraulic Works of the Ministry of Public Works—Mr. George Duclout—a graduate of Zurich, and an expert, in every sense of the word, in all scientific work of this kind.

For the information of the readers of Engineering News the following facts are stated: The Ministry of Public Works is preparing for the St. Louis Universal Exposition, under the supervision of Mr. H. M. Lange, the Director-General of Hydraulic Works, very complete illustrations of all the features of interest in the rivers treated in this article. They will consist of relief models of the rivers, models of dry-docks, numerous charts, plans and photographs, albums of photographs showing the dredging plant and Government work shops, the floating equipment of the hydrographic parties of engineers, plans and charts of the buoying of the channels, maps of the upper rivers, and models and plans of their ports and plans for improvement, etc., etc.

Although not connected with the immediate subject in hand, the exhibit being prepared by Chevalier Luiggi, the Director-General of the Military Port, should be referred to. This will be of great interest to all engineers who have to do with ports. There will be a printed description in Spanish and English of the works, as executed up to the present time, a plan of the estuary of Bahia Blanca, where the port is located, the general plan of the naval station, and of the works completed and to be executed.

There will also be plans of the great masonry dry-dock, one of the large ones of the world, and a model of the same, also models of moles, cofferdams and of the quay walls in various stages of construction. These exhibits will be found in the Engineering Department of the Palace of Liberal Arts, under the charge of the Director of Liberal Arts, Mr. Ockerson, M. Am. Soc. C. E.

It may be added that other Departments of the Ministry of Public Works will have interesting exhibits—Irrigation, Roads and Bridges, Water-Works, Railways, Architecture, etc.

The Minister of Public Works, Dr. Emilio Civit, entered upon his ministry with the earnest desire to improve the navigation conditions of the great rivers considered in this article. How well he has succeeded will be seen by an examination of the exhibits at St. Louis, and to him are engineers of all countries especially indebted for the very complete exhibition of the features above mentioned of his important Ministry.

The Argentine Government is determined to have at the Exposition a complete exposition of that great Republic—our antipodes and all of its ministries and departments, its resources and principal characteristics will be represented.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication: new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday at 10 a. m.

Only a few weeks ago we printed a paper which instituted a close comparison between the cost of alternating current and direct current operation of interurban electric railways. The author of that paper, Mr. P. M. Lincoln, is identified with the engineering work of one of the large American electrical manufacturing companies, and his paper is an expression of the fact that there is a widespread and active interest focusing on alternating current traction. Though at present not a mile of commercial electric railway in this country is operated by alternating current, yet the extension of electric traction to lengths of line of twenty, fifty, and one hundred miles is bringing about an ever-increasing overlap of the fields of electric traction and of long-distance power transmission; and to-day this latter field is dominated by the alternating current.

During the past three years there have been projected in this country two electric railway lines planned to be operated by cars using alternating current directly in the motors: the Washington, Baltimore and Annapolis Ry. in Maryland, which was to be equipped with the series alternating current motor developed by the Westinghouse Electric & Mfg. Co., the system referred to in Mr. Lincoln's paper above noted; and the Lansing, St. Johns & St. Louis Ry. in Michigan, to which Mr. B. J. Arnold is applying his original and peculiar system of "electro-pneumatic" driving.

Little information about the progress on these two railways has leaked out since the first very general announcements* concerning them. For this reason especial interest resides in the article on another page of this issue, in which Mr. Arnold presents a fairly detailed description of the machinery which has been developed to put his system into practice. The publication of this information at the present time is due to an unfortunate accident, which has given the system a setback of months, a fire which destroyed the finished machines, as related in a letter from Mr. Arnold, also printed in this issue.

A study of Mr. Arnold's article will show that the machinery necessary to apply his system is rather complex. His car combines the mechanism of an electric car with that of a compressed air locomotive, and in addition has a controlling valve mechanism for securing the proper relative action of the two parts. This latter element will largely determine the success of the system, since upon it depends the efficiency and reliability of the whole machinery. The article does not describe this valve mechanism. Evidently it has a diversity of functions to perform, in properly balancing the electric and pneumatic actions during the successive periods of standing, starting, running, retarding, and reversing, of the car. To design a suitable device to fulfil these various functions seems not an easy mechanical problem. Mr. Arnold has assured us, however, that he has solved this problem to his full satisfaction, by an arrangement which is simple as well as reliable.

Assuming that this arrangement is perfectly successful, i. e., that by its means the air engines geared to the motor may be made to equalize the varying load, torque and speed requirements at all times, without sacrifice of reliability or material drop of efficiency, then the system may be said to promise the best combination of the advantages of the direct-current system and high-tension alternating-current transmission that has yet been claimed. The induction motor without equalizing device, as it has been adopted for several alternating-current railways in Europe, lacks in flexibility and adaptability to varying service conditions. The series alternating-current motor, which has been used in Italy by Mr. Finzi and is being developed here by the Westinghouse Electric & Mfg. Co., has a commutator and hence is restricted to low voltages; it must, therefore, have step-down substations, or, if it is desired to use high voltage in the trolley wire, there must be a transformer on each car. The "compensated" induction motor, which is now being tried in traction work by one of the large German electric builders, requires several conductors, like the plain induction motor. The Arnold system not only uses single-phase current (requiring but a single trolley wire), but is not limited in voltage; Mr. Arnold intends to work with 5,000 to 10,000 volts in the trolley wire.

In weight of car equipment his machine doubtless far exceeds any other system. For, while he requires less motor capacity, there are two air engines, the air storage tanks, and (usually) a small motor generator set and storage battery to supply the valve-controlling magnets and the car lights. Applied to a locomotive, this weight will not be a disadvantage, since it will be necessary to get the required tractive force; but with ordinary cars there may be difficulty in providing for the additional bulk and weight. In addition, there is always the objection of inherent dangerous character to any high-voltage trolley system, as we urged three weeks ago in commenting on Mr. P. M. Lincoln's paper.† Whether this objection will be overridden or not is a question of the future, but we doubt whether the public and the responsible authorities will permit high-voltage trolley lines to be installed, if at all, without better guarantee of safety than is afforded by present practice in car wiring and operation.

Although the project has been delayed, we take particular pleasure in describing in this issue the proposed subways for pipes and wires for which bids were to be received in New York city on Dec. 29. This journal has long advocated the adoption of such a system by American cities, and we earnestly hope that nothing will prevent the awarding of a contract and the building of the subways. It is a great pity that like provision for pipes and wires was not made along the whole extent of the new underground railway. All interested in the future welfare of the city should see to it that pipe and wire subways are built along every foot of extension to the underground railway system.

Some object lessons of the results of excessive concentration of power supply are furnished by two recent accidents to electric central stations. The first occurred in London on Dec. 5; it is reported in the London "Electrician" as follows:

> At 10.30 a. m. last Saturday, just when the fog was at its thickest, an entire failure of supply took place at the Ecclestone-place station of the Westminster Electric Supply Co. The armature of a 225-KW. machine developed a short circuit, and before it could be switched off all the other machines pulled up and the entire station had to be shut down. . . . . The battery being used almost entirely for balancing had been provided with only light fuses, and these naturally blew. For about half a minute the station was in complete darkness, until the emergency lights supplied by the battery came on. But by that time the mischief had been done, and as it was impossible to start up against full load all feeders were switched off, the undamaged machines started up, and feeders switched on one at a time until the normal supply was resumed.

The effect of the accident was, therefore, to leave an entire section of the city without electric light or power for the time that the interruption lasted. What might result from such a condition, even if the interruption should last only half an hour, anyone familiar with modern city conditions can picture for himself.

The other accident befell the engine end of an electric plant. The Boston "Herald" reports it thus:

> WARREN, R. I., Dec. 23, 1903.—With a crash that shook every inch of the great electric power station of the New York, New Haven & Hartford Railroad located in this town, both cylinder heads of the great stationary engines blew asunder this morning, bringing the entire plant to a standstill. The crossheads were also shattered, and other minor damages resulted from the explosion.
>
> This station supplies the current for the operation of trains on the Providence, Warren & Bristol branch, one of the company's steam lines to which electricity was applied several years ago. It will require fully a week to make the necessary repairs, and meantime the service will be carried on by locomotives.

The immediate cause of either of these two accidents is of no matter: whether or not the accidents were preventable, the fact remains that apparently unaccountable accidents will happen, as the list of constantly occurring railway accidents indicates. Every refinement of "protective devices" will probably not be sufficient to prevent them altogether. Increasing centralization in electric stations tends to make more and more depend vitally upon the operation of a single station, or even a single engine-unit, on the plea of economy in operation. It is well to keep in mind the reasons against this tendency: the rapid increase in the complexity and cost of adequate protection against accident as the size of station increases, and the increase in "insurance" charge (whether upon company or public) necessary to cover the risk of loss by interruption of service.

In further reference to the disastrous derailment of Dec. 23 on the Baltimore & Ohio R. R., and as additional support for our editorial note of last week concerning this accident, we present the following news report, taken from the "Journal" of Deposit, N. Y.:

> WRECK NEAR HANCOCK.
> (From our Hancock Correspondent.)
>
> An eastbound fast freight Saturday evening (Dec. 12) had an unusual mishap west of here. A car loaded with bridge irons just a few cars from the caboose, in some way loosened the protecting boards and the irons fell to the ground, one perpendicularly, and as the caboose went by, stove in the entire side, scattering the furniture and occupants in every direction. No serious injury was received by any of the men.

The proximate cause of the accident here is precisely the same as that which wrecked the "Duquesne Limited" and sent sixty-five persons to death. Freight shipped on a flat car and held by sideboards and stakes shifted in transit and knocked out the sideboards, so that some of the material fell from the car. In the present case the damage was insignificant, and (what is unusual) affected only the train from which the

*"An Electro-Pneumatic Traction System," Eng. News, July 3, 1902, and "An Electric Traction System Employing Single-Phase Alternating Current," Eng. News, Oct. 2, 1902.

†In this connection see Mr. Lincoln's letter in this issue replying to our comments of Dec. 17.

material was dropped. But to learn that precisely the same thing may be the cause of great disaster we have only to remember the wreck of the "Duquesne Limited." Danger of similar disaster must always reside in insecure stowing of material on railway cars.

We illustrated, in our issue of Oct. 22 last, a peculiar bridge used in connection with an electric towing system on the Miami & Erie canal. As we then stated, a regular electric railway track was laid down on the canal towpath and electric locomotives were built to run on it and tow canal boats. Inasmuch as the depth of water in the canal is only about four feet or less and the traffic on it is insignificant, it appeared to us from the beginning quite inexplicable that such an expenditure should be undertaken merely for electric towing.

It is now stated that the company will appeal to the legislature for permission to operate its towing railway for the general carriage of freight and passengers, and abandon boat towing, and it is alleged that this was its real intention at the outset, the electric towing scheme being merely a subterfuge to gain possession of the towpath with its railway track. This last charge is brought by the representatives of a rival syndicate, who likewise want the use of towpath for an electric railway line and who foresee difficulty in ousting the company now in possession.

The situation is particularly noteworthy because the establishment of an electric towing system on this canal was heralded far and wide as an evidence of the return to favor of waterway transportation. If we mistake not this argument was used in the barge canal canvass in New York last fall. Its absurdity is evident enough now.

The terrible disaster in a Chicago theater on Dec. 30, as a result of fire and panic, is fully described in this issue in an article prepared by a member of our editorial staff after a personal inspection of the building, and a study of all available information as to the circumstances of the disaster. In that article the extent to which inadequate exits and inadequate means of checking the spread of flames contributed to the disaster is fully discussed; and what we wish to particularly lay stress on here is the influence which Chicago's fearful holocaust should have in bringing about a safer construction of all places of public assemblage, and particularly with regard to adequate means of exit in case of emergency.

There are literally thousands upon thousands of churches, halls, school buildings, stores, hotels, and factories, as well as theaters, in this country in which the danger of a panic and resultant disaster is as great as and frequently far greater than it was in the Iroquois theater, Nor are these dangerous places by any means confined to the large cities. The worst examples are frequently to be found in country villages. In fact, it is the exception instead of the rule to find such assembly places provided with adequate means for exit. It is the general rule to have such halls located in the upper stories of buildings, and reached by one or two flights of stairs, which are often steep, narrow and winding. The means of heating and lighting such structures often involve much risk of fire, and inflammable decorations are frequently hung about on special occasions in utter ignorance of the dangers which they involve. It is true that the use of such places of assembly is infrequent as compared with the use of a theater; yet when they are used they are often filled to the limit of their capacity, and it is common to find movable seats, chairs placed in aisles, and standing room occupied, and every one concerned entirely ignorant that any danger is thus incurred.

We sincerely hope that the horror at Chicago may serve as a warning to thousands of communities, and may be a strong influence toward bringing about safer construction for all places of public assembly.

Not one engineer or architect in a hundred or a thousand ever has any responsible part in the planning of a theater, but a very large proportion of our readers may at some time have a voice in determining the plan of some place of public assembly. We would, therefore, emphasize the fact that provision of adequate means of exit should be considered the most necessary part of any such place.

We say this in full knowledge of the fact that when a crowd of hundreds of people are seized with panic in endeavoring to escape from imminent danger, there is every probability that casualties will result no matter what provision may exist for safe and speedy escape. In illustration of this fact we may instance the panic, wholly without cause, which occurred at the opening of the Brooklyn Bridge in 1883, when 14 people lost their lives through the pressure of a panic-stricken crowd, which piled up in a dense mass in passing down a short flight of stairs. A much more recent and still more notable example was the disaster in connection with the coronation ceremonies at Moscow a few years ago, when the pressure of crowds upon an open plain caused a great number of casualties.

But because the best precautions cannot wholly eliminate danger from panic, it does not follow that these precautions should not be taken. The better the means of exit, the greater the number that may be saved if panic occurs. From the best figures available it would seem that over two-thirds of those in the Iroquois theater escaped with their lives. Had all the means of exit been in condition for immediate use, the casualties would probably have been greatly reduced.

The provision of adequate exits from all places of public assembly, therefore, is not only worth while; but their omission is a crime against the public safety. Engineers and architects are in a position to understand this fact, and appreciate its importance to a far greater degree than others. It is their duty to exert their influence whenever and wherever opportunity offers toward proper provision for public safety, and the terrible disaster at Chicago will doubtless lend force to many an argument for safe construction that would otherwise fall upon deaf ears.

The note in our issue of Nov. 26 urging the adoption of standard sizes for trade catalogues is reprinted with approval by the "American Machinist," which then inquires why we "continue to waste good space, type, ink and paper by printing *Catalogue*? Why is not *Catalog* a good standard to adopt also?"

In reply we may say that in our opinion life is too short and important matters too pressing for a technical journal—or any other journal, for that matter—to set up its own standards in the matter of spelling. We adopted the Century Dictionary as our standard for spelling many years ago, and to that arbiter all disputed matters in that line are referred.

A REVIEW OF THE STEEL CAR SITUATION.

When the steel car began to be introduced into general service in this country a few years ago, it was considered as presenting a problem with many difficulties for the mechanical and equipment departments. These difficulties included the higher first cost and the unknown factor of life or durability, but were regarded as especially serious in regard to repair and maintenance. It was predicted that not only would the repair expenses be high, but that it would be extremely difficult for railways to repair bent and distorted parts, while corrosion would add greatly to the difficulties. While it was known that metal underframes and metal cars had been extensively and successfully used in foreign countries, there was a wide impression that similar results might not be obtained in this country. In spite of various objections and prejudices, and of numerous practical difficulties that were encountered from time to time, the steel car has made steady and rapid progress, and is now generally accepted as a valuable addition to railway equipment, particularly in introducing economies in both the mechanical and the transportation departments.

It has been found in this case, as in many other cases, that when the problem was actually attacked it proved much less difficult or serious than when considered merely in anticipation. As a matter of fact, with thousands of steel cars now in service, the general result is that repairs are very much lighter and corrosion is much less serious than had been expected, while repairs are readily made. The actual life under the severe conditions of service remains to be determined, but a comparison of steel and wooden cars on the basis of first cost, maintenance expenses and durability, indicates that for cars of 40 tons capacity and over, employed in the heavy trains and severe conditions of modern freight service, the steel car has decided advantages in both efficiency and economy.

The steel car is essentially a modern proposition on American railways. Although a few steel or iron cars have been in use for 15 to 20 years, and although experimental designs for steel cars began to be put forward about twelve years ago, yet the steel cars of the types now so largely used date back only about five to seven years, and in fact some of the designs are of much more recent date. In presenting this subject at the convention of the Master Car Builders' Association in 1902, Mr. W. H. Lewis, Superintendent of Motive Power of the Norfolk & Western Ry., stated that in 1897, the principal manufacturer of steel cars (the Schoen Pressed Steel Car Co.) turned out 501 cars, while in 1901 it turned out 24,590 cars, and the total number of cars built up to June, 1902, was about 61,000. Assuming that other makes of steel cars would bring the total number up to 70,000, that number would represent only 5% of the total freight car equipment of the country. But by June, 1903, the Pressed Steel Car Co. had built nearly 100,500 cars of steel or with steel underframes, and it is probably safe to assume that there are now 125,000 steel or steel framed cars in service, without reckoning wooden cars with steel center sills. There are now about 1,600,000 freight cars (exclusive of cars in company's service), and the steel and steel framed cars would represent nearly 8% of the total equipment. The majority of these cars, as noted in the article which we print in another column of this issue, are owned by eastern railways, while few of the important western trunk lines have yet made any extensive use of steel cars.

The length of experience with steel cars is as yet insufficient to enable any definite statement to be made as to durability, and this is especially the fact for the reason that some of the earlier steel cars have proved too light for the service, and the expense in repairing these cars in some cases has been higher than that for wooden cars. These cars, however, cannot fairly be compared with modern wooden cars, since they represent the experimental stage of the steel car. If the steel cars are built strong enough for the service (and this does not necessarily involve excessive dead weight), their mantenance expenses will most probably be lower than for wooden cars in the same service, although the indications are that these expenses will be higher than they need be owing to peculiar forms of abuse to which the cars are often subjected. While the steel cars may fairly be considered as having passed beyond the experimental stage, it is still subject to further development and improvement, especially as to its details of construction, and in fact improvements and new designs are continually being made. Leaving this aside, however, the question at the present time is as to the efficiency and economy of those steel cars which are now in use and are at least strong enough for regular service.

This subject was discussed at the annual meeting of the Master Car Builders' Association in June, and while various defects or objections in detail were referred to, the general experience and opinion were decidedly in favor of the steel car. Mr. Humphrey, of the Chicago & Alton Ry., stated that he had watched the steel cars very closely for 18 months and was surprised to find that with the exception of repairs necessitated by wrecks, and occasional repairs to the trucks and coupling attachments, there were practically no repairs required. On the Norfolk & Western Ry. and other lines, similar results have been obtained, as noted further on.

In the case of cars wrecked or worn out beyond repair, the salvage or scrap value of the steel car will of course be very much higher than for a wooden car, and this scrap value has been estimated at $10 per ton, or, say, $150 to $175 per car. In case of wreck, steel cars sustain much less damage than wooden cars, and steel parts that

are bent and distorted can be straightened and made of service, while in wooden cars the broken and smashed timbers are useless and almost valueless. It is true that broken wooden sills can be easily replaced, while the straightening of a steel sill may involve time and difficulty. But on the other hand the steel sills are so much the stronger that an accident which would distort them very badly would probably wreck a wooden car beyond possibility of repair.

One of the great advantages of the steel car and the steel underframe is the great longitudinal strength to resist the shocks and stresses transmitted to it by the draft gear. Tests made with heavy trains of loaded 50-ton steel coal cars on the Lake Shore & Michigan Southern Ry., by a committee of the Western Railway Club, in 1902,* have shown that the tensile stresses in draft gear may range from 50,000 to 80,000 lbs. with ordinary handling, and up to 100,000 lbs. with rough handling, while the buffing stresses were from 100,000 to 300,000 lbs. Under these conditions of service, which are becoming more general every day, it is no wonder that the draft attachments to wooden cars give continually increasing trouble, and it is this particular trouble which has led some roads to introduce steel center sills, while not yet ready to accept the steel car as a whole. The above figures also indicate the advantages of friction draft gears for cars used in this sort of service. In fact, when some modern wooden cars on the Chicago, Burlington & Quincy Ry. were equipped with an improved draft rigging capable of sustaining the most severe shocks, the whole draft rigging was pulled away from the sills, breaking the sills in two. In discussing this subject in our issue of Jan. 30, 1902, it was pointed out that many modern cars are equipped with draft rigging very little stronger than that of older and lighter cars, and further that there is no probability of a reduction in size or weight of locomotives and cars, so that existing conditions must be reckoned with in the design of draft rigging and its attachments.

Officers at the head of the mechanical departments of many important railways have put themselves on record as recognizing that steel car construction is no longer experimental, and that in view of modern conditions of train service steel should at least be used for the underframes of cars of over 40 tons capacity. While the cost of repairs and maintenance cannot yet be definitely obtained, it is the general opinion (based on experience) that the ultimate cost of a steel car (taking first cost, maintenance and durability into account) will be materially less than that of a wooden car. With cars of lighter capacity, the weight of the steel underframe would probably be greater than that of the wooden underframe. Of course this opinion is not universal. A few consider that a 50-ton car should be the lowest limit for a steel underframe, as 40-ton cars would cost $100 to $125 more with steel than with wooden frames, and the difference in cost would not warrant the expense. Others believe in the steel gondola and flat car, but not in the steel box car. The cost of car repairs is estimated by Mr. Van Alstine, of the Chicago Great Western Ry., at $21 per car per year for wooden cars ($11 for material and $10 for labor), and $18.25 for steel cars, both making 7,300 miles. He takes the first cost at $800 and $950, and depreciation at 5% and 3% per annum, respectively. With a saving of 8% in annual expense in favor of the steel car, he does not favor the 20% extra first cost for cars of 20 and 35 tons capacity.

In the design of wooden box cars it has long been a matter for controversy as to whether the side trusses should or should not be utilized to carry a part of the weight of the load, and the general opinion seems to be that the underframe should be made strong enough to carry the load, entirely independent of assistance from the upper side framing. In steel car construction, however, there is no doubt as to the advisability of using the sides to carry a proportion of the load. In hopper and gondola cars the sides may be built as plate girders, and thus dispense with individual side sills, or they may be riveted to the latter, which then form the bottom chords of the girders. In this way a very stiff and substantial framing is ensured, and a reduction in weight may be effected. In box cars, the entire side may be a complete truss, with the side sill forming the bottom chord and the plate forming the top chord. A similar trussing is also sometimes adopted in composite gondola cars, the sides having a truss framing to which the planks are attached. Up to the present time steel upper framing for box cars has not come into extensive use, but box cars with steel underframes are very numerous. The Chicago & Alton Ry., for instance, has adopted a steel underframe as standard for box, stock, refrigerator and furniture cars. It is said, however, that a box car with steel upper framing can be built to weigh 1,500 to 2,000 lbs. less than a wooden car of the same capacity and dimensions, a steel underframe being used in both cases.

*Proceedings, Western Railway Club, May, 1902.

In regard to the dead weight of cars, the following statement as to the design of 50-ton cars was made by Mr. Seley (Chicago, Rock Island & Pacific Ry.) in a paper before the Richmond Railway Club:

> Say the car shall carry 110,000 lbs. maximum load, and that the revenue freight shall be 75% of the total weight. This means that the light weight shall not exceed 36,666 lbs., and that the ratio of dead to live load is 33⅓%. If the trucks are to weigh 15,000 lbs., it will leave 21,666 lbs. for the body. This is feasible, but not in a wooden car. The frame at least must be of steel, the castings of malleable iron, and all members carefully calculated. It is feasible to build 40-ton hoppers or gondolas to carry 88,000 lbs. with a ratio of dead to live weight of 37%, which means 73% revenue load, or 2% less than for the 50-ton car.

No direct comparison can be made between the weights of steel and wooden cars, as the respective weights vary so much in cars of different designs. The length, depth, cubic capacity and structural strength must also be taken into account, as a mere comparison of dead weight and tonnage capacity is of little use. Besides this, the actual weight of the contents must be considered, for a car holding 50 tons of one class of coal might hold more or less of another kind of coal, or iron ore. The cubic capacity is therefore an important element in the comparison. This is shown by the following tables, which shows the variation in a comparison of twelve steel hopper-bottom cars of nominally 50 tons capacity, and which also gives a comparison of gondola and box cars.

	Length, ft.	Weight, lbs.	Capacity, tons.	Capacity, cu. ft.
Hopper-Bottom Cars.				
B. & O. (steel).....	30	36,300	50	1,590
C. & O., "	28	37,700	50	1,920
D., L. & W. "	40	37,000	50	3,290
Gondola Cars.				
C. & A. (steel)....	38	32,450	44	1,270
C. & A. "	41	38,700	50	1,522
C., B. & Q. "	40	38,000	50	1,615
C. & E. I. "	43	37,890	50	1,520
Erie "	40	40,900	50	2,045
C.,B.&Q.(composite)	40	39,500	50	1,400
Box Cars (Steel Underframe).				
Pennsylvania	38½	45,000	50	2,448
Sou. Pac.	38	36,200	40	2,448

As to a comparison of steel and wooden cars in the coal service it is to be noted that the Pittsburg & Western Ry. (now included in the Baltimore & Ohio Ry. system) formerly carried 640 tons of coal in 18-car trains, or 35½ tons per car. When it introduced steel cars it carried 940 tons per 18-car train, or 52¼ tons per car. The Norfolk & Western Ry. also averages 50 tons of coal in its steel cars. A comparison of weights and capacities of trains of steel cars and wooden cars was published in our issue of Jan. 19, 1899.

Composite cars with steel underframes and wooden sills, sometimes with steel stakes or upper frames, have been tried on several railways, but apparently without any particular advantages over the all-steel cars, although some designers favor them. The Chicago & Alton Ry. purchased 500 composite gondola cars and 800 steel gondola cars in 1900, all of 100,000 lbs. capacity, but weighing 41,000 and 35,000 lbs. respectively, or 6% in favor of the steel cars. These were described and illustrated in our issue of Feb. 26, 1903. The two styles of cars were identical in construction, with the exception of the floors and sides; they were mounted on the same kind of trucks and operated in the same service. Up to June, 1903, none of the cars had cost anything for regular repairs, but wreck repairs on the steel cars were less than on the composite cars, the latter sustaining more damage in the upper part. As to corrosion, this has been more serious on the composite cars, since the wooden floor and sides become saturated with water and thus keep water (containing sulphur and other injurious elements from the coal) in contact with the steel. The Norfolk & Western Ry., in 1899, built about 1,000 cars of 50 tons capacity with structural steel underframes and a wooden body. These weighed about 40,000 lbs. Mr. C. A. Seley (then of the N. & W. Ry.) took the same design of car but with steel truss sides, and the weight was about 2,000 lbs. less than the others. The same experience was had with 400 box cars of wood and 100 with steel framing up to the roof plates, the latter weighing about 1,600 lbs. less than the former. The N. & W. Ry. now has 55-ton composite cars 31 ft. long weighing 39,600 and carrying an average load of 52 tons.

On a good many railways, and more particularly those of the western section of the country, while it is admitted that steel cars are no longer experimental and that their increased use may be expected, there is still a certain prejudice against them, partly on account of the higher cost and partly on account of an impression that considerable changes in design may yet be made. But where these ideas prevail, there is very often a tendency to introduce steel underframes or at least steel center sills on account of the continual trouble with draft rigging on wooden center sills. At the 1903 meeting of the Master Car Builders' Association, Mr. J. J. Hennessey, of the Chicago, Milwaukee & St. Paul Ry., expressed the opinion that the advantages of metal underframes remain to be proved, but he advocated the use of steel center sills, as follows:

> I believe that if good yellow pine is used, the side sills and intermediate sills of a woden box car will last from 15 to 25 years. We have not built a 30,000-lb. car since 1878, but we have a number of them in service, with the original side and intermediate sills. The center sills have been replaced, probably many times. I believe that in building wooden cars hereafter, they should be constructed with metal center sills which will receive the buffing and pulling strains in direct line with the center sills and not above or below them. It does not matter whether such metal sills are pressed steel or rolled I-beams or channels.

At the same meeting, however, Mr. W. F. Bentley, of the Baltimore & Ohio Ry. (with about 16,000 steel cars), said that the average wooden car will not meet the requirements of the heavy service of to-day for any length of time, and that the railways will be compelled to use steel cars, or at least steel underframes, to ensure economical service. At the meeting of 1902, also, the use of steel center sills on wooden cars was discussed, and several speakers objected to this construction, on the ground that it is not possible to properly unite steel and wooden members, and that the greater deflection of the wooden sides and intermediate sills would result in throwing too large a proportion of the load on the center sills. When wooden cars are used, the application of steel center sills enables them to be successfully operated in the same trains, but when steel cars and ordinary all-wooden cars are coupled in the same train the latter are subjected to very severe treatment.

In conclusion it may be said that the steel car is evidently far beyond the merely experimental stage, and that its use has already disproved some of the objections originally raised against it. But on the other hand it is still open to considerable improvement in design and construction. As to box cars, the advantages of the steel underframe are well established, and a development in the use of steel upper framing may also be looked for. The composite car is still in the experimental stage, and more experience will be required before it can be compared with the all-steel car. As to the use of steel center sills, this seems to be a wise and economical method of construction for wooden cars, in view of the continual increase in car loads, train loads and engine power, and the consequent increase in trouble with the draft rigging and its attachments.

LETTERS TO THE EDITOR.

Should Azimuth Be Measured from the South?

Sir: In turning angles right and left it is customary to set the zeros on plate and vernier together. When repeating angles the engineer generally starts from zero and runs around the plate to the right (in the direction the

clock hands travel—or clockwise, as the "trig." books put it. Instruments are generally graduated these days with two sets of graduations. One from 0° to 360° (clockwise) and the outer graduations in quadrants corresponding to the needle box graduation. Many engineers set the zeros together with the needle reading true north at the starting point of a survey, and read all the bearings directly from the plate to minutes, the swinging needle guiding them in placing the N—E—S—W letters if they read the outer set of graduations. If they use the complete circle they reduce to quadrant angles by well known rules and use the needle bearings as a check.

It is convenient to start always from zero. As the north pole has always been a point to count from, and the telescope when erect points to the north side of the compass box, it is convenient to call the north zero. The writer has used the azimuth system for nearly twenty years in this way, because when he went to school the rules were as follows, to reduce azimuths:

(1) Angles less than 90° are N E.

(2) Between 90° and 180° subtract from 180° and call S E.

(3) Between 180° and 270° subtract 180° and call S W.

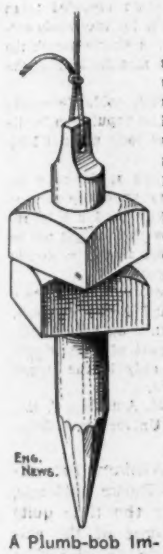
(4) Between 270° and 360° subtract from 360° and call N W.

Why does Johnson's surveying count the azimuth from the south instead of from the north?- Why will engineers have to change from the simple plan of putting the zeros together and get into the habit of putting the 180° mark under their eye? Is there any good reason? This letter is called out by an article on the "True Azimuth in the Hawaiian Islands," page 519, in your issue of Dec. 10.

Engineer.

St. Louis, Mo., Dec. 12, 1903.

An Improvised Plumb-Bob.



A Plumb-bob Improvised in an Emergency.

Sir: Last summer I had a party ready to go to work when it was found that the plumb-bob had been left in the office ten miles away. A track-laying gang was at work very near us, and I sent an axman to them to get a nut from a track bolt, expecting to suspend it so that one of its corners would serve as a point, but before he returned I had conceived the design shown in the accompanying sketch; one or preferably two nuts, screwed on a piece of wood whittled to the proper shape and size.

My reason for thinking that this may be worth the space it will occupy in your journal is that when a transitman finds himself short of a plumb-bob, let him remember that a serviceable and accurate one can be made with a straight stick 6 ins. long and one or two nuts, which can generally be obtained from an old plow or something similar at the nearest farm house.

Yours truly,

Arthur Pew.

Hawkinsville, Ga., Dec. 5, 1903.

The Concrete Pavements at Bellefontaine, O.

Sir: In your issue of Aug. 27, 1903, a "Subscriber" from Athens, Pa., asks whether concrete pavements have been used anywhere in the United States, and if they have proved satisfactory. Editorially, you answer that concrete pavements have been tried in a few alleys in Philadelphia, and that such pavements tried in Grenoble, France, have been reported to be very satisfactory.

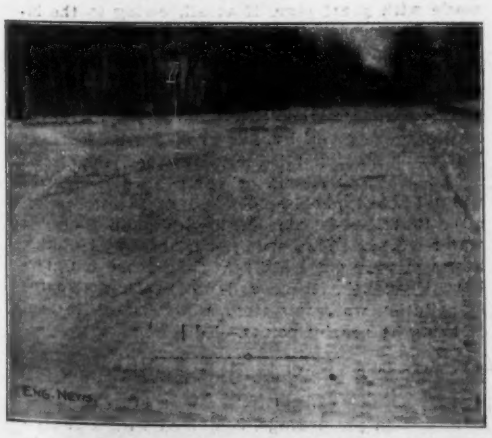


Fig. 1. Concrete Pavement at Bellefontaine, O., After Some Ten Years' Use.

In the Engineering News of Jan. 3, 1895, you published a brief description of concrete pavements constructed in Bellefontaine, O., Mr. G. W. Bartholomew, Treasurer of the Buckeye Portland Cement Co., being the author of the description.

As I visited Bellefontaine last March to examine those streets for my own benefit, and while there had an opportunity of meeting the contractor who laid the streets, I may be able to add some items of interest to the above-mentioned description.

There are portions of four streets paved with concrete. They surround the court house, which is located in the heart of the city. Two of the streets are quite narrow and two are full width streets. The two narrow streets were constructed in 1892, while the broad streets were built in October and November, 1893.

The ground in that locality is rolling, and is underlaid with gravel forming an excellent material for roadbed. The concrete was laid upon a well compacted roadbed in two layers; the foundation layers 4 ins. and the surface layer 2 ins. thick. In the two narrow streets the foundation course was composed of 1 part Portland cement to 5 parts coarse gravel; and the surface coat, 3 cement to 5 of coarse sand. In the two broad streets the proportions were changed to 1 part Portland cement and 4 parts gravel for the concrete used in the foundation, and 1 cement to 1 of sand for the surface layer. The sand used in the surface coat might be termed torpedo gravel, as the screen used in screening it had meshes ⅝-in. in dimensions.

During the laying of the concrete on the main streets in the fall of 1893 the weather was quite cold; according to the contractor, "it froze nearly every night." The fresh laid concrete was covered with sawdust each night during construction. To allow for expansion, tarred paper was used in the joints between the blocks, which were from 5 to 6 ft. square. The concrete was tamped with rammers 8 ins. square and weighing 35 lbs. The surface coat was put in place quite dry and well rammed; then the surface was sprinkled to make it wet enough to work well under a wooden float. The surface was then rolled with a metal imprint roller in order to give a good foothold for horses.

I enclose some pictures, taken while there, which will show the present condition of the streets after nearly ten years of wear. On the main streets, where the traffic was not so closely confined, the surface showed little effect from ten years' service. In Fig. 1 the imprint pits are clearly discernible. No cracks of any importance showed in any of the streets. The results of a defective method of construction is shown in Fig. 2, where the traffic is crowded into narrow limits upon one of the narrow streets and has worn down the cutting lines, demarking the stone blocks to a depth of nearly 2 ins. in some places.

The contractor cut his blocks in lines running longitudinally with the streets and at right angles thereto. This street is also laid to drain towards the center, where one of the demarking lines came.

It was quite easy for teamsters to drive with one wheel in the depression and the wearing has resulted. This might have been avoided if the blocks had been cut by lines running diagonally across the street. On one of the main streets the paving was worn down so that the imprint pits do not show through the dust.

Mr. Bartholomew states in his article that these streets cost $2.15 per sq. yd., including filling, drains and curbs. With the extremely small amount of repairs which the streets show to have been done upon them, they have certainly been an economical investment for the city.

By the census of 1900 Bellefontaine was given a population of 6,050, which will give some idea of the amount of traffic to which these streets are probably exposed.

I am indebted for much of my information to Mr. W. T. G. Snyder, of Bellefontaine, the contractor who constructed these streets.

Respectfully yours,

F. H. Eno, Professor of Municipal Engineering.

Ohio State University, Columbus, O., Dec. 5, 1903.

Alternating Current Traction for Interurban Railways.

Sir: I note that you have printed in your issue of Dec. 17 the paper read by me before the Canadian Society of Civil Engineers entitled "Interurban Electric Traction Systems—A. C. vs. D. C." I further note that you have made editorial comment on this paper and have raised some objections to the system delineated. In this communication I wish to answer some of the objections which you have pointed out.

On the score of voltage you take exceptions to the high voltage trolley proposed in these words, "A 3,000-volt alternating current is something to be handled with respect . . . and those responsible for the safety of passengers will certainly hesitate before they place such an agent over the roof and lead it down the trolley pole to the machinery carried on the car loaded with passengers."

In regard to this point, I wish to draw attention to the fact that practically all of the apparatus on the car may be placed in the low tension side of the car transformer. The only high-tension on the car, therefore, consists of the high tension winding of the transformer, the circuit from the trolley to the transformer and a circuit breaker or similar device. These can be protected so as to make the escape of current practically impossible. The part of the apparatus from which the current is most liable to escape, viz.: the motors and control apparatus are at voltages which are lower than present D. C. practice. It is a question, therefore, whether or not the A. C. equipment is not really preferable to the present D. C. equipment on the score of safety to passengers.

Further, in regard to this matter of trolley voltage I wish to point out that a low trolley voltage can be used, retaining at the same time practically all of the advantages of the A. C. system. This may be done by simply multiplying the number of A. C. substations and therefore multiplying the number of points at which the energy is fed into the secondary distributing system. By this means the energy may be taken very near to the point of use on the high potential transmission line, say 15,000 volts or more, and the distance of transmission at the lower trolley voltage may be cut down to anything desired. The objection to this is the somewhat increased cost of substations, but since the substation item in the case cited in my paper amounts to only about 7½% of the total electrical equipment, it is evident that considerable increase can be made in this item without materially affecting the total first cost of electrical equipment.

To quote again from your editorial, "Another point that will be noticed in the alternating current proposition is that the electrical equipment of the car weighs 6.3 tons more than the D. C. equipment." In regard to this point, I would state that the figures in my paper were based upon apparatus which had already been built and successfully operated at the time the paper was written. Newer designs and future improvements will constantly tend to decrease this difference in weight and instead of the A. C. equipment being 18% heavier, as assumed in my paper, future equipments will probably be reduced in weight so that this difference will not be more than from 5 to 10%.

To quote once more, "The adoption of the alternating current system will save . . . only 10% of first cost." In regard to this, I wish to call your attention to the fact that the difference between the cost of the two systems as given in my paper amounts to a little over 18% of the cost of the D. C. system and a little over 22% of the cost of the A. C. system.

Yours very truly,

P. M. Lincoln.

Westinghouse Electrical & Mfg. Co., Pittsburg, Pa., Dec. 29, 1903.

The Single-Phase Electric Traction System on the Lansing, St. Johns & St. Louis Ry.

Sir: As many of your readers know I have persistently advocated the use of the alternating current directly in the motors for electric railways for several years. (See Trans. Am. Inst. Elec., 1900, 1901 and 1902.). By referring to the discussions which took place at these meetings, and to the technical papers, it will be found that until recently there were few, if any other advocates in this country of the alternating-current motor for railway work, and that those who supported it abroad advocated the use of three-phase currents until within the last few months. Since my announcement of the principles of my system before the Great Barrington convention, the development of the single-phase alternating-current railway motor has made remarkable strides, both in this country and abroad, and while at that time it had few friends, the development has been such since that it now seems

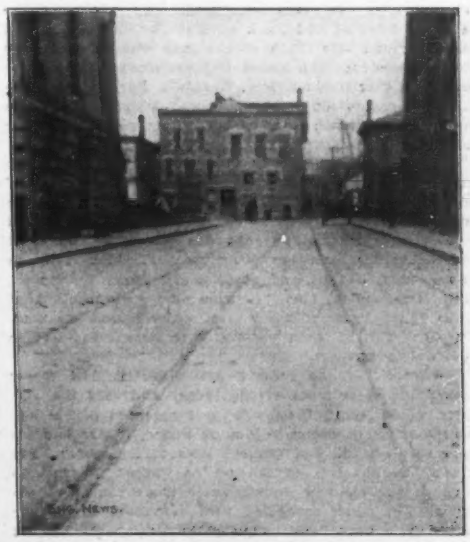


Fig. 2. Concrete Paving at Bellefontaine, O., Worn in Ruts Along the Joints.

destined to take its place as the leading railway motor, thereby effecting a revolution in electric railway work.

Many of your readers also know that since announcing

the principles of my system before the Great Barrington convention I have refrained from giving out any further information regarding it, giving as my reasons therefor my desire to test the system thoroughly before making further public statements regarding it, and then to present a full and complete description of it, together with the results of its operation, in the form of a paper before the American Institute of Electrical Engineers. Consistently pursuing that policy I have conducted my experiments privately and at my own expense, and had so perfected my apparatus that I had hoped to be able to celebrate the incoming of the year 1904 with a public demonstration, over twenty miles of railroad, which would conclusively prove that the single-phase electric railway is not only operative but efficient, and less in first cost and operation than any system now in vogue, not meaning to imply thereby that the system which I have developed was necessarily the only system or the best system, for only time can prove the correctness of such statements, but that it was a system which would successfully do the work, and the system which was first developed and first to be put in actual operation upon the first electric railway in the world especially built for single-phase alternating current motor operation.

That I would have made a demonstration on Jan. 1 was a certainty to me until Dec. 18, when I learned by telegraph while in New York that the car barns, located at Lansing, Mich., of the road upon which I had been experimenting, were completely consumed by fire at 4 o'clock that morning. The fire, apparently, originated from a stove in the engine house and was communicated so rapidly to the car barns that it destroyed a steam locomotive and two new cars built for my system, as well as my experimental locomotive, thus leaving me unable to make the demonstration as I had planned. In view of the fact, however, that the single-phase electric railway is now receiving so much attention at the hands of engineers and inventors in many parts of the world, and that I believe that the year 1904 will be an epoch-making one, marking the revolution from the direct-current to the alternating-current motor for railway work, as well as the beginning on a large scale of the displacement of the steam locomotive on railways (with the use of a substantial form of overhead construction rather than the third rail), and from the further fact that I cannot get another machine ready in the near future, I have concluded that I will give to the technical press a record of my work up to the present time in order that it and the system which I have developed may be properly weighed in comparison with the work and systems of others, leaving the more complete description of the system and the results of its operation to be presented at a later date.

In January, 1900, I rode over the country between Lansing and St. Louis, Mich., a distance of about 60 miles, with a party of gentlemen who desired to build an electric road between these points. This trip resulted in my advising them that the territory was such that I believed the road should be built as economically as possible, and inasmuch as they desired me to assist financially in its construction I told them I would do so provided I was allowed to construct the road in accordance with certain ideas that I then had in mind, for by such construction the first cost of the road could be kept sufficiently low to warrant its construction, and that if it were built on any one of the systems standard at that time the advisability of building it was questionable. The result was that on April 23, 1900, a contract was entered into wherein I undertook to build and equip the road. Engineers were at once placed in the field to locate it, and after the plans were sufficiently completed, the grading, bridging and track work of 20 miles of the road followed, and this much of the road was completed, to such an extent that steam trains were put in regular operation over it about Nov. 15, 1901. For financial reasons the completion of the road was delayed, and in the meantime the development of my system was taking place and the parts being perfected in different offices and shops.

Since it was my intention to experiment with pressures as high as 15,000 volts on the working conductor, all of the line material had to be specially designed, but the work progressed to such an extent that the overhead and line work of 20 miles of road was practically completed and ready for operation about Dec. 15, 1902, and the power installed so that experiments began in March, 1903. On June 15, 1903, two trips were made, each about three miles long, with my first experimental machine. On the first trip seven persons were aboard and on the second trip thirteen.

The result of the experiments with the first motor proved the correctness of the theory and that the machine would work. Inasmuch as it consisted of but one somewhat crude electro-pneumatic motor, it was impracticable to get full and efficient tests of the system, and it was thought best to conduct no further experiments until a complete new double-motor truck could be perfected. Not being connected with manufacturing establishments, I have been compelled to develop this system under trying circumstances, necessitating the construction of parts in different shops and assembling them at far distant points with crude facilities. This fact, combined with the financial difficulties that have arisen, and the necessity of my having to give the main part of my attention to other matters, have been the causes of the delay in completing the road and the system.

A new double-motor equipment, in the form of a locomotive, was finally built and brought to perfect working condition on the evening of Dec. 17 (see drawings Fig. 9 of Mr. Arnold's article in another column of this issue. —Ed.), and it was this locomotive with the necessary instruments for testing purposes that was destroyed by fire the following morning. Since it is going to be impracticable for me to get a new one constructed for some time, I have thought best to state the facts as outlined above, and give a description of the apparatus and the road, reluctantly omitting the records of operation and the tests which I had hoped to have accompany any future statements I made, but which through the irony of fate must now be left for the future.

I hand you herewith a hastily prepared description of the road and the system, which I trust will be found sufficiently comprehensive to interest your readers.

Respectfully, Bion J. Arnold.

Chicago, Dec. 26, 1903.

(The description and the drawings and views accompanying it are presented in another column of this issue.—Ed.)

Water Pollution and Typhoid Fever in Pennsylvania.

Sir: Your article on "Some Lessons of the Butler Typhoid Epidemic" in your last issue seems to have an undercurrent of opposition to water companies, and for some years past you have taken the position that the public should furnish its own water supply.

Without discussing the question as to which is the best method for furnishing a supply of water for domestic and manufacturing purposes, I desire to call your attention to one point, so far as it relates to the state of Pennsylvania. For thirty years I have been interested in the construction and operation of works for the supply of water to the public, and I might say incidentally that it was a paper read before the Engineers' Society of Western Pennsylvania that resulted in a joint commission of three members each from the Engineers' Society, the Allegheny County Medical Society, the Pittsburg and Allegheny Chamber of Commerce, and the Society of Microscopy. This joint commission stirred up the question of a better water supply, which finally resulted in the Filtration Commission of the City of Pittsburg. The laws of the state of Pennsylvania required water companies to furnish a pure water supply, and the courts, whenever a case has been before them, have compelled a compliance with the law. But in the case of a municipal water supply the law is silent, and in the words of one of the judges of Allegheny County, "The city could deliver mud and the people would be helpless."

Your criticism of Pittsburg is none too severe, as the city has an example within its own limits. I do not have records with me, so give from recollection only: In 1896 the Pennsylvania Water Co. installed a filter crib in the Allegheny River, the average effluent of which has averaged 95% of the bacteria removed. This water supply has been for several years supplied to the 37th ward of the city of Pittsburg, and the records of the Health Department show that the 37th ward has 85% less typhoid than before the introduction of the filtered supply and about the same percentage less than the adjacent ward supplied by the municipality.

Some ten years ago the owners and managers of the water companies of Pennsylvania formed an association for mutual assistance, one of the principal objects of which was to protect the water supply.

About six years ago the Pennsylvania Water-Works Association, in connection with the state and local boards of health, presented to the legislature of Pennsylvania a proposed act for the prevention of the pollution of streams, and for the purification of the water supply. The proposed act would have compelled all water supplies to be pure, and municipalities would have been compelled to observe it, as well as private companies.

The act was introduced in the senate and passed, but when it reached the house it was referred to a committee and that was the end of it. Those that know how such things are done can form their own opinion as to why the bill was not reported, but my belief is that the coal and oil interests and the manufacturers and politicians did not want the bill passed.

At the time the bill was in the house committee, a senator told the writer he thought the bill would not be reported, as there was not enough money in it. In reply to this the senator was told no money would be paid to get the bill out of the committee, and as the object was entirely for the protection of the health of those using the water supplies, the committee must assume the responsibility.

In the opinion of the writer those having charge of the water supply to the public are morally, if not legally, responsible for a large part of the typhoid deaths, and as far as the water companies of Pennsylvania are concerned they are more desirous to furnish a pure water supply than are the municipalities. Respectfully,

James H. Harlow, M. Am. Soc. C. E.

Baltimore, Md., Jan. 2, 1904.

(We certainly intended to make it clear that the municipalities of Pennsylvania and the government of the State were grossly negligent in the matter of protecting their citizens from water pollution. We are glad to have the water company interests present their side of the case. If there is anything to be said in behalf of the public of Pennsylvania we should like to hear it also. But most of all we should like to see the water companies and the public join in an intelligent, determined crusade against endangering public water supplies and against supplying impure water to unsuspecting citizens.—Ed.)

The Grand Forks Water-Borne Typhoid Epidemic of 1893-4.

Sir: In Dr. Soper's tabulation of statistics of typhoid epidemic at the close of the report upon the Butler outbreak, in your issue of Dec. 24, 1903, it appears that the epidemic at Grand Forks, N. Dak., in the winter of 1893-4, which was described in your issue of May 23, 1895, should be included, as it goes considerably beyond any of those cited in the percentage of morbidity and mortality based on population.

For four months of the epidemic the record, on the lines of Dr. Soper's tabulation, was:

Place.	Date.	Pop.	Cases.	Deaths.	Cause.
Grand Forks, N. D..	1893-4	4,979	1,245	96	water

Confining the data to one month, the second of the outbreak, we have 712 cases and 52 deaths.

From this it will be seen that while Dr. Soper's table the highest percentage of the population reported taken with the disease was 13.8, at Plymouth, for the whole outbreak, in the case of Grand Forks for a single month the morbidity was 14.3% and for the four months 25% of the population.

In the matter of deaths the Plymouth epidemic stands first in Dr. Soper's table with 1.4% of the population, while at Grand Forks there were during the four months 1.9% of the population dying.

The Grand Forks epidemic, though one of the most instructive on record, seems to have very generally escaped the attention of students of epidemiology, and a brief resume of the circumstances connected with it might not be out of place in the present connection, nearly a decade having passed since the original publication.

I have more than once felt deeply grateful to your paper for presenting to its readers the Grand Forks epidemic, which, so far as I have learned, is only on record elsewhere in an exhausted edition of a report of a practically defunct board of health, to be found only in the largest libraries. Very truly yours,

Gardner S. Williams, M. Am. Soc. C. E.

Hydraulic Laboratory of Cornell University, Ithaca, N. Y,. Dec. 31, 1903.

[We are grateful to Professor Williams for calling to our attention the Grand Forks epidemic, the seriousness of which had for the time quite escaped our memory. Our account of the epidemic was included in an article on the slow sand filters at Grand Forks, which were constructed soon after, and largely because of the epidemic. Following out Professor Williams' suggestion, we have reprinted the substance of our account of the outbreak elsewhere in this issue.

We may add that close comparisons of the several epidemics, based on populations, should be made with great care, if at all, owing to the invariable uncertainties attending population figures for intercensus years. Thus, in Dr. Soper's table the populations given are estimates, while the population of Grand Forks, repeated by Professor Williams from our issue of May 22, 1895, is the figure given by the U. S. census for 1890. But after making all due allowances, the Grand Forks outbreak should probably head the list of water-borne typhoid epidemics. It is to be noted, also, that it was connected with publicly-owned water-works. The conditions at Grand Forks, however, were quite different from those at Caterham, Plymouth, Ithaca and Butler, for the source of pollution was some sixty miles distant, instead of being at nearby points.—Ed.]

THE PROPOSED BEGINNING OF SUBWAYS FOR PIPES AND WIRES IN NEW YORK CITY.

Injunction proceedings, combined with a change of administration, have again made uncertain the proposed installation of the beginning of a system of subways for the multitude of pipes and wires now buried in the streets of New York city.

The plan, which has been at least temporarily set aside, provided for pipe and wire galleries in a portion of lower Broadway to be built coincidently with the rapid transit subway, but under a separate contract and administration. That is, the work described herein was under the direction of Mr. Jacob A. Cantor, until Jan. 1 Borough President of Manhattan, and the plans have been prepared by Mr. James C. Bayles, Consulting Engineer, 41 Park Row, New York city.

The subway would have a total length of 1,835 ft. It would begin just north of Fulton St., or a block or two south of the General Post Office, and, except for the break noted below, would extend down Broadway to Morris St., or two blocks south of Wall St. A general plan of a part of the subway is shown by Fig. 1, while Fig. 2 shows it in section and Fig. 3 includes details of the manholes.

The space (see Fig. 2) available for the subway, or pipe and wire galleries, is strictly limited by the pavement above, the roof of the rapid transit subway below, the curb line on either side, and the underground electric railway in the center except that the galleries for the wire ducts can be carried deeper. At and either side of Rector St. the vertical space is so small as to necessitate the omission of the new subway for a distance of 365 ft.

In general it may be said that the pipe galleries are from 4 to 7 ft. high in the clear, and 8 to 10 ft. wide, while the wire galleries are some 2 ft. wide by 3 ft. high.

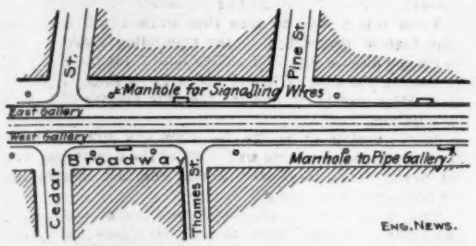


Fig. 1. Plan of Part of Proposed Pipe and Wire Subways, Lower Broadway, New York city.

It will be seen (Figs. 1 and 2) that there are two pipe galleries, one on either side of the street, and likewise two pairs of galleries for wire ducts. Each of the latter consists of a gallery for signalling wires, above, and the light and power wires, below, the galleries for the two classes of wires being entirely separate, and provided with independent manholes.

The various manholes, and the openings from the gallery for light and power wires to each building along the subway, are shown by Fig. 3. Special attention is directed to the pipe gallery manholes, which are designed to permit cast iron pipe to be rolled into the pipe galleries.

Concrete-steel is to be used throughout, except that in the case of manholes brick may be substituted, at the option of the engineer. An 8-in. vitrified drain pipe at either side of the street is to be connected with the galleries, for draining the latter, at intervals of 50 ft.

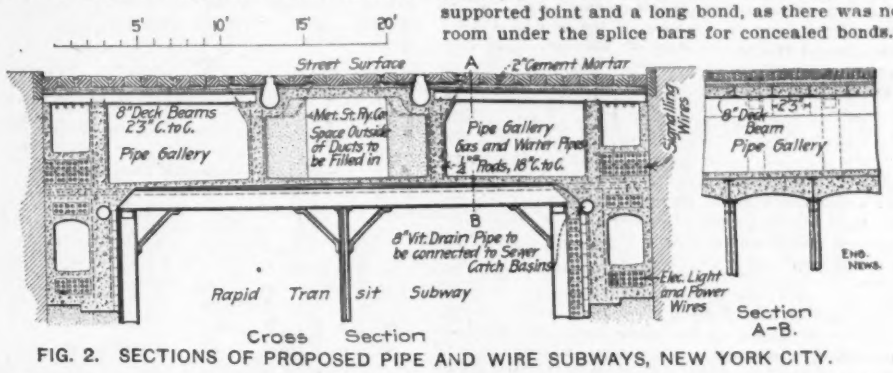

5' 10' 15' 20'
Street Surface
A
2" Cement Mortar
8" Deck Beams 23" C. to C.
Pipe Gallery
Met. St. Ry. Co. Space Outside of Ducts to be Filled in
Pipe Gallery Gas and Water Pipes
Rods, 18" C. to C.
Signalling Wires
9" Deck Beam 23" H
Pipe Gallery
B
8" Vit. Drain Pipe to be connected to Sewer Catch Basins
Rapid Transit Subway
Elec. Light and Power Wires
ENG. NEWS.
Cross Section
Section A-B.

FIG. 2. SECTIONS OF PROPOSED PIPE AND WIRE SUBWAYS, NEW YORK CITY.

We are informed that the general plan and details for this work have been cordially approved by hydraulic, gas and electrical engineers; that the project has attracted a great deal of attention in other cities; and that requests have been received from all parts of the country for copies of the plans and specifications.

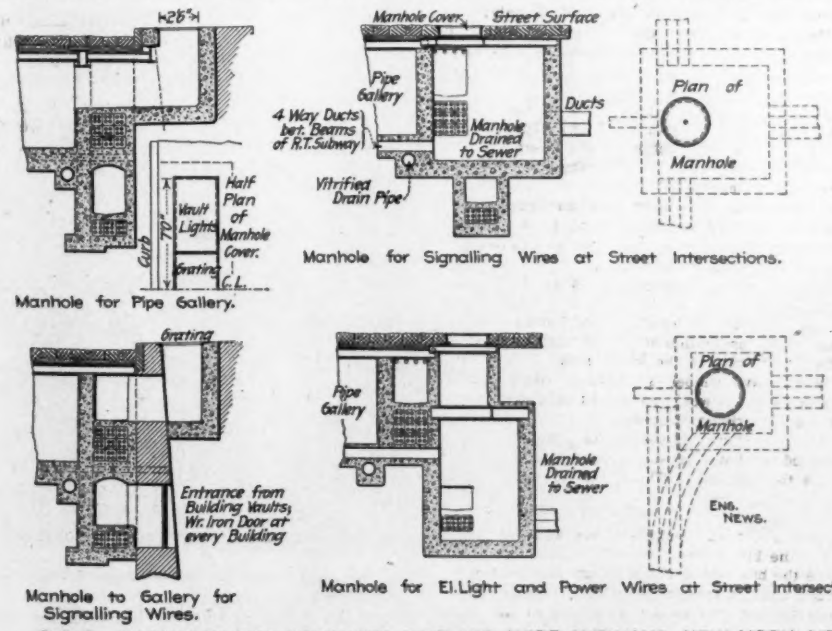


FIG. 3. MANHOLES FOR PROPOSED PIPE AND WIRE SUBWAYS, NEW YORK CITY.

THE ARNOLD ELECTRO-PNEUMATIC RAILWAY SYSTEM; ITS APPLICATION TO THE LANSING, ST. JOHNS & ST. LOUIS RY.

By Bion J. Arnold,* M. Am. Inst. E. E.

ROADBED AND TRACK.—The Lansing, St. Johns & St. Louis Railway was originally projected to extend from Lansing, the capital of Michigan, northward through St. Johns, Alma and St. Louis, a distance of about 60 miles, but up to the present time only that portion extending from Lansing to St. Johns, a distance of 20 miles, has been constructed. The road was built in accordance with regular railway practice, with easy grades and curves, so that steam locomotives could be operated over it until such time as electrical equipment could be put upon it; the idea being to complete the road in such a manner that it could be utilized for both freight and passenger service, and thus secure all the business available from the territory through which it passes.

The road is equipped with 67-lb. T-rail, laid on ties spaced 2 ft. apart between centers, and, as high-tension alternating current was to be used, but one of these rails was bonded, with 38-in., 4-0 bonds extending entirely around the splice bars. Since it was impossible to secure rails from the rail manufacturers in time, rails and splice bars were secured from one of the leading steam railways, and this necessitated the adoption of a supported joint and a long bond, as there was not room under the splice bars for concealed bonds.

The road as at present constructed between Lansing and St. Johns has no grades exceeding 1%, and no curves exceeding 7°, except in the cities themselves, where the terminals of the road run over the streets and make such curves as ordinary street cars make, the minimum radius being 50 ft. At each city a terminal was planned so that all freight would be diverted to connecting steam roads, thus making it unnecessary for the freight service to pass over the city streets or curves. At the Lansing end it was necessary to pass over the steam railway tracks of the Pere Marquette R. R., and this necessitated the construction of a bridge with pile approaches; the grade as approached from the Lansing end is 4% for a distance of about 700 ft., and after passing over the bridge the descending grade is 2.3% for about 500 ft. At the St. Johns end there is a grade on the principal street of the town averaging about 2% for about 1,500 ft.

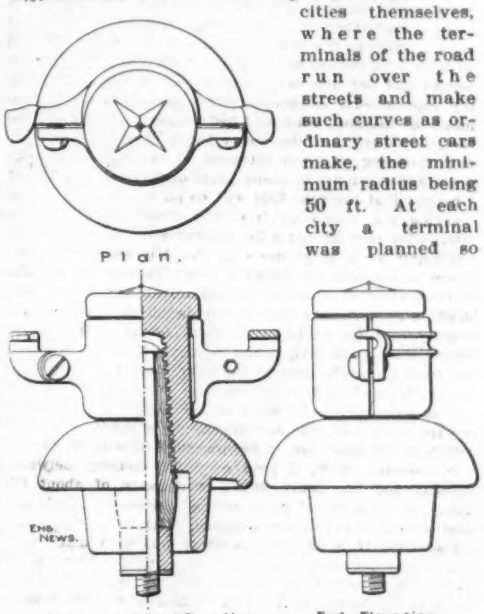


Fig. 1. High-Voltage Trolley-Line Insulator.

OVERHEAD CONSTRUCTION.—Considerable care was taken in planning a suitable insulator for carrying the trolley wire, on account of the high voltage to be used. Fig. 1 shows the construction of the annealed glass insulator finally adopted. These insulators have shown an average strength of 30,000 volts, under test. Fig. 2 shows the typical arrangement of the straight line overhead construction, and it will be noticed that wood is used for the pole, cross-arm and brace, and that the insulator is supported by means of a short span wire from iron brackets secured to the wooden cross-arm. This construction insured a high insulation at a low first cost, the entire line having been constructed for but a slightly increased expense over the cost of standard construction, and at the same time so built that in case of failure of the alternating motor system, the standard direct-current motor system could be put into service without changing any parts; even holes for the pins for carrying the extra feeders which would be required were provided, as shown.

*Consulting Electrical Engineer, 1541 Marquette Bldg., Chicago, Ill.

It will thus be seen that the line and track were constructed in such a manner that no expense was incurred for any parts which would not be required for standard construction in case it became necessary to ultimately adopt the standard direct-current motor system; the entire idea in the construction of the road being to save first cost and to invest all that was invested in such a manner that all material purchased would be utilized in case either system were adopted, and should the alternating system prove successful the additional investment for a direct-current motor system need not then be installed.

The working conductor was placed 22 ft. above the tops of the rails in order that trainmen standing upon the tops of the freight cars going over the road could not come in contact with the working conductor.

It was planned to operate the entire road from a single 2-0 trolley wire and with one rail bonded as hereinbefore mentioned; this amount of copper being sufficient to operate four 40-ton cars at an average speed of 30 miles per hour with power house located 1½ miles from one end of the line, and operating with from 6,000 to 10,000 volts on the working conductor.

The power house is located at one end of the line, because the electric company from which power is purchased by the railroad has a water power at this point. Current is transmitted to the nearest end of the line over two No. 3 wires. The power is furnished from a 300-KW. rotary converter generating at 380 volts and 25 cycles, the energy from which is stepped up to the working pressure of the line. It was the intention after experimenting a sufficient length of time to determine the best voltage for the working conductor to have the generators for the permanent plant constructed so as to generate at this determined voltage, and it was for this reason that a temporary rotary converter was first installed to conduct the experiments with.

It was planned to use a bow-trolley to take the current from the trolley wire, as is indicated in the drawings of the locomotive, Fig. 9. In the experiments actually made on the line, however, an ordinary wheel-trolley was used, the highest voltages contemplated not having been reached.

During the preliminary experimental period upon the apparatus described below, all power was transmitted from the above-mentioned power house to a point about two miles distant, where were located the car barns in which the preliminary experiments were made.

EQUIPMENT.—The principles on which the new system of traction for which this road was designed is based were laid down in a paper read by

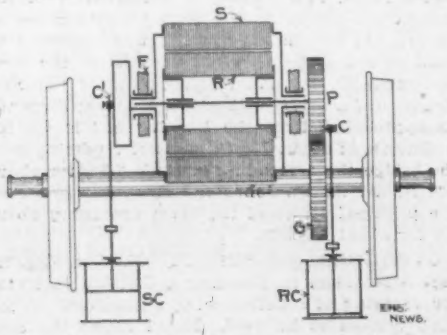


Fig. 3. Diagram of Arrangement of Electro-Pneumatic Motor.

Lansing, St. Johns & St. Louis Ry.

R—Rotor.
S—Stator.
R C—Cylinder of Rotor Engine.
S C—Cylinder of Stator Engine.
P—Pinion on Rotor.
G—Gear on Car Axle.
C—Rotor Crank-pin.
C'—Stator Crank-pin.

the author before the American Institute of Electrical Engineers on June 19, 1902 (reprinted in Engineering News of July 3, 1902).

In brief, the essential elements of the system are: (1) A single-phase or multi-phase alternating-current motor mounted directly on the car, designed for the average power required by the car, and running continuously at constant speed and constant load, and therefore constantly at maximum efficiency; (2) A reversible air engine whose crank-pin is connected to the stator of the motor; (3) A similar engine connected to the rotor; (4) Air-storage tanks on the car which either supply one or both of the air engines or are

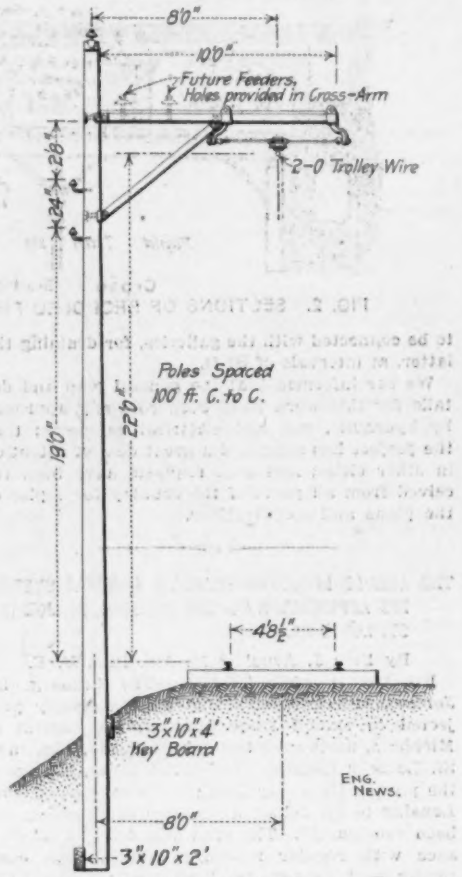


Fig. 2. Standard Line Construction on Tangents.

charged from one or both of the engines; (5) A valve gear by which either or both engines can be made to run as compressor or as engine, to suit the speed and torque requirements of the car at any moment.

What this system is intended to secure is the efficient utilization of an alternating-current motor while yet giving a full range of car-speeds from zero to maximum, without diminution of torque. Further, a certain amount of power storage is secured, so that the cars may run across gaps in the supply conductor, etc. This last is an almost necessary condition for the success of a high-tension railway system.

The following description and the accompanying drawings and views will serve to make clear the application of the principles of the system and the arrangement of its working parts:

Fig. 3 represents diagrammatically the principal working parts. The rotor R of a single phase induction motor is geared to the axle of the car by the pinion P attached to the rotor; a crank pin C secured in this pinion drives the compressor engine R C. The stator S can also revolve, independently of the rotor, and it is fitted with a crank pin C', by which it is connected to the compressor engine, S C. Both engines are piped to air reservoirs located under the car, and are also provided with suitable valves manipulated from a single controller on the car platform for making them perform their various functions. Thus, the entire regulation of the speed and power of the car is controlled by the air cylinders, and no other regulating devices are necessary.

The valves of the two air cylinders are electrically controlled so as to make it possible for each cylinder when driven by the electric motor to compress air into the tanks, and when operated by compressed air to furnish mechanical energy for moving the car. When, for instance, the cylinder is compressing air the valves work like inlet and outlet poppet valves of a common air pump, while on the other hand if the cylinders are supplied with compressed air each valve is operated electrically by a pilot solenoid connected with the valve seat in such a manner that the energy for moving the valve is supplied by the compressed air, thereby making the valve practically self-actuating. The time of operation of the valves is controlled by a series of collector rings revolving with the engine shaft, and their regular operation is interrupted and varied to suit the requirements by means of the motorman's controller.

When a rotary or turbine type of air engine is used all of the above valves and reciprocating parts are eliminated and the entire controlling mechanism consists of two air valves operated from a single engineer's valve which may be located upon the platform of the car or in the cab of the locomotive, and so arranged that one or more units may be operated from the platform or cab of any unit without the necessity of connecting wires between the units.

Since the motor may be of the simplest type of induction motor without a commutator, and the system does not require the manipulation or breaking of the main current, the motor may be designed for any working voltage and be of any type which will maintain a constant speed when provided with a constant load. This eliminates the necessity of all step-down transformers, resistances or other regulating devices and confines the current to the motors themselves, and as these are below the car floor the danger from the current is reduced to the minimum.

On account of air storage and other features of this arrangement, the electric motors can be much smaller in capacity than those of other traction systems not possessing an equalizing load feature, and the capacity of the power house and line can be reduced to about one-half of what would be required with systems where the fluctuating starting loads of the cars are transmitted back to the power house.

The different operations of the system are summarized in the speed diagram, Fig. 4; here the abscissas represent the different car speeds in per cent. of the normal or synchronous motor speed, while the ordinates represent the rotor and stator speeds corresponding to the car speeds shown. The upper line, O C R, gives the rotation speed of the rotor, while the line A D S gives the stator speed. Ordinates above the base line O D L represent positive or forward rotation, while ordinates downward from O D L represent reverse rotation.

CAR AT REST.—When the car is at rest, the rotor (being geared to the axle) is evidently also standing still, while the stator runs reversed with full synchronous speed. The stator is then transferring the full energy of the electric motor through crank C' (Fig. 3), to the compressor cylinder SC, which energy is being delivered in form of compressed air into the air reservoir.

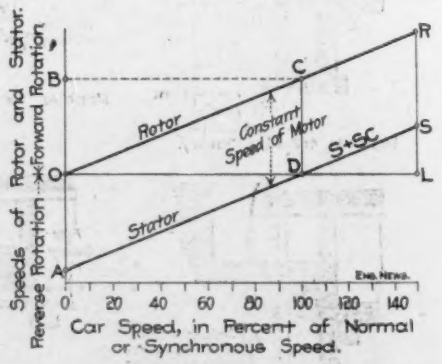


Fig. 4. Diagram of Rotor and Stator Speeds.

Since the relative velocity between the stator and the rotor is, under all conditions of operation, constant, the speed curves of stator and rotor, O C R and A D S in Fig. 4, are parallel lines. The origin O of the given co-ordinate system represents the period of rest of the car, and, therefore, indicates zero rotor speed and full stator speed in a negative or downward direction, as the stator is now revolving in the opposite direction from that which the rotor must revolve to drive the car forward.

Let it be further assumed that O A equals the active torque of the stator, then it will be easily understood that O B, which equals O A, represents the reactive torque of the rotor exerted on the car axle. When the car is at rest the rotor is held by moving the controller to such a position that the outlet pipe from rotor cylinder R C is throttled.

STARTING AND ACCELERATING.—To start the car the air cushion behind the piston of cylinder R C is freed by shifting the valve, and the air compressed air disappear. If the rate of acceleration is such that cylinder R C uses all of the air supplied by cylinder S C no exhaust to the atmosphere from cylinder R C takes place.

Since the electric motor runs always at constant speed and under constant load it has a constant torque, and, therefore, the distance between lines O C R and A D S in Fig. 4 may be considered as representing the energy delivered by the electric motor. The length of any ordinate extending from O D to O C represents the proportionate amount of energy derived from the electric motor which is applied directly through pinion P and gear G to the propulsion of the car, while the corresponding ordinate extending below O D to A D represents the proportionate amount of the energy of the electric motor which is absorbed in compressing air through cylinder S C, which energy, in the form of air, is immediately transferred to cylinder R C and is utilized in accelerating the car.

FULL SPEED.—When the rotor has reached full synchronous speed by the previous operation, this speed can be maintained by moving the controller to another position which will throttle the outlet pipe of cylinder S C until the reaction due to the pressure behind the piston equals the full torque capacity of the electric motor. An overload or underload may be placed upon the motor by varying this pressure, but under normal conditions of operation cylinder S C is provided with an automatic valve which keeps a constant pressure behind its piston, thus maintaining an absolutely constant load upon the electric motor and consequently a uniform demand of electrical energy from the line.

With the controller set at full speed position the inlet valves of rotor cylinder R C are held open and the piston runs free and the electric motor now gives its full power to the car axle, and the stator and its air mechanism will remain at rest as long as the car runs at the speed corresponding to the synchronous speed of the motor.

SPEED VARIATIONS.—There are usually certain places on any road where high rates of speed can be maintained for short distances, and as these speeds might be higher than the synchronous speed for which the motor was designed they are provided for as follows: Assuming that the car is running at synchronous speed the controller may be moved to such a position that the valves of stator cylinder S C operate in such a manner as to cause it to act as an engine and revolve stator S in the same direction as rotor R is revolving. This now causes, owing to the constant electrically maintained difference in speed between the stator and the rotor, an increase of speed of the rotor and car axle, due to the motor automatically working as a magnetic clutch, without mechanical contact, and if the resistance of the car or train is less than the capacity of the electric motor the air necessary for revolving the stator can be obtained, hot, from the rotor cylinder R C, without drawing from the tanks, and a speed above synchronism indirectly proportioned to the resistance of the train maintained indefinitely. When the resistance of the train is greater than the capacity of the electric motor, speed above synchronism can be obtained only by supplying stored air from the tanks, and can only be maintained for short distances, or until the storage capacity of the air reservoirs is exhausted. This condition corresponds to the spurts that can be made by a steam locomotive when working above the steaming capacity of the boiler. The distance from the line O D L to that portion of the line A D S above O D L in Fig. 4, represents, at any given speed, the proportionate amount of energy which must come from the tanks and be

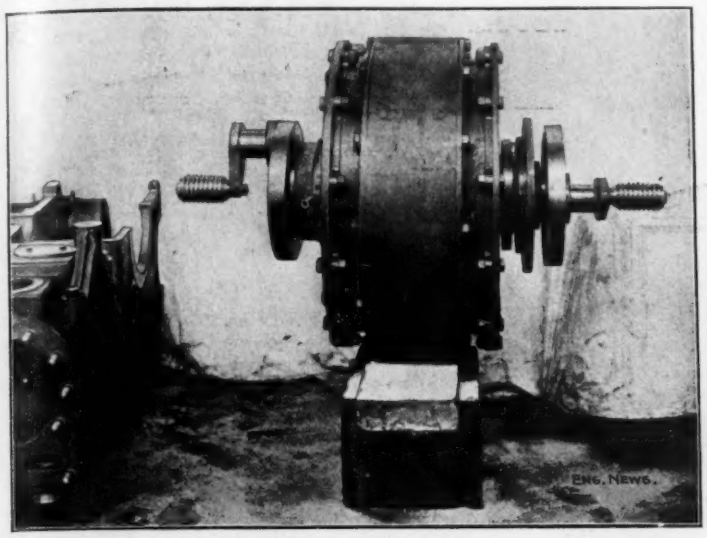


FIG. 5. ELECTRIC MOTOR COMPLETE.

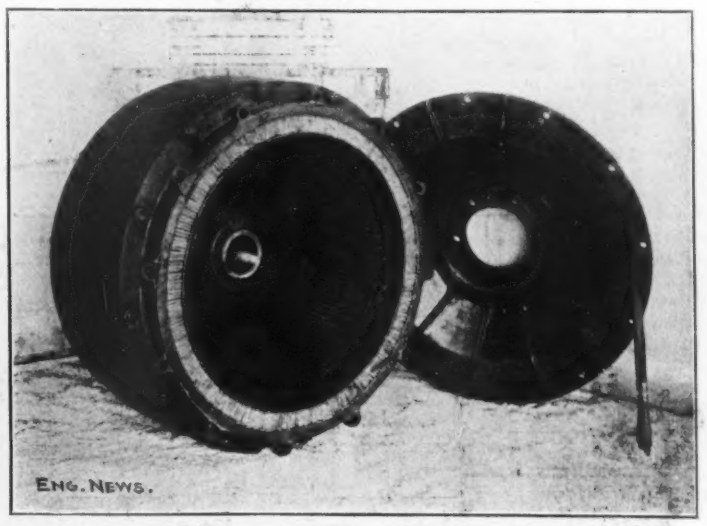


FIG. 6. STATOR AND END-PLATE.

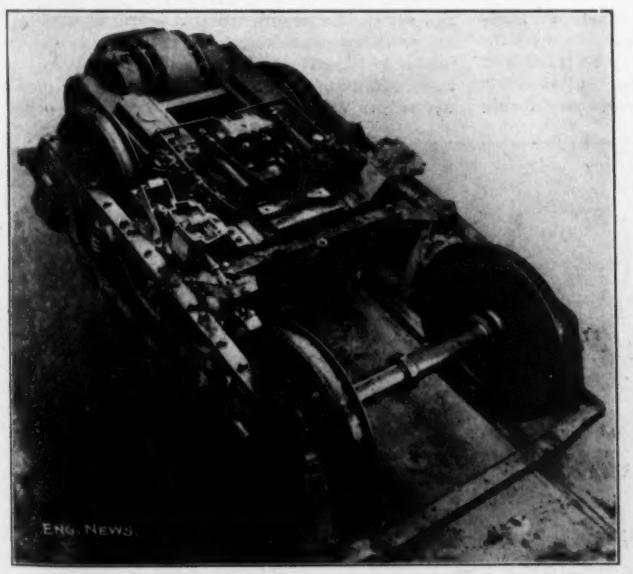


FIG. 7. FIRST ELECTRO-PNEUMATIC MOTOR TRUCK; SINGLE MOTOR.

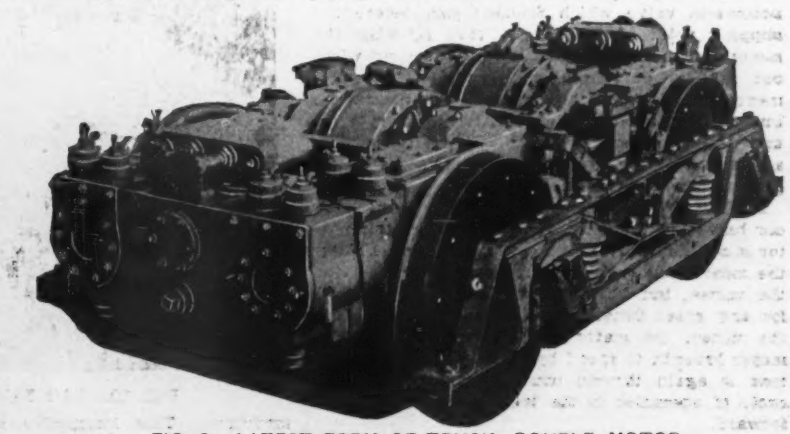


FIG. 8. LATEST FORM OF TRUCK, DOUBLE MOTOR.

During this period of acceleration the air compressed by cylinder S C, instead of being delivered to the tanks to lose its heat, is delivered, hot, directly to the rotor cylinders, thus greatly increasing the efficiency of the combination, as the heat usually lost in air systems is utilized and the advantages of heated air gained without a re-heater, and as the pressure used is low (about 100 lbs.) many of the ordinary difficulties in the use of

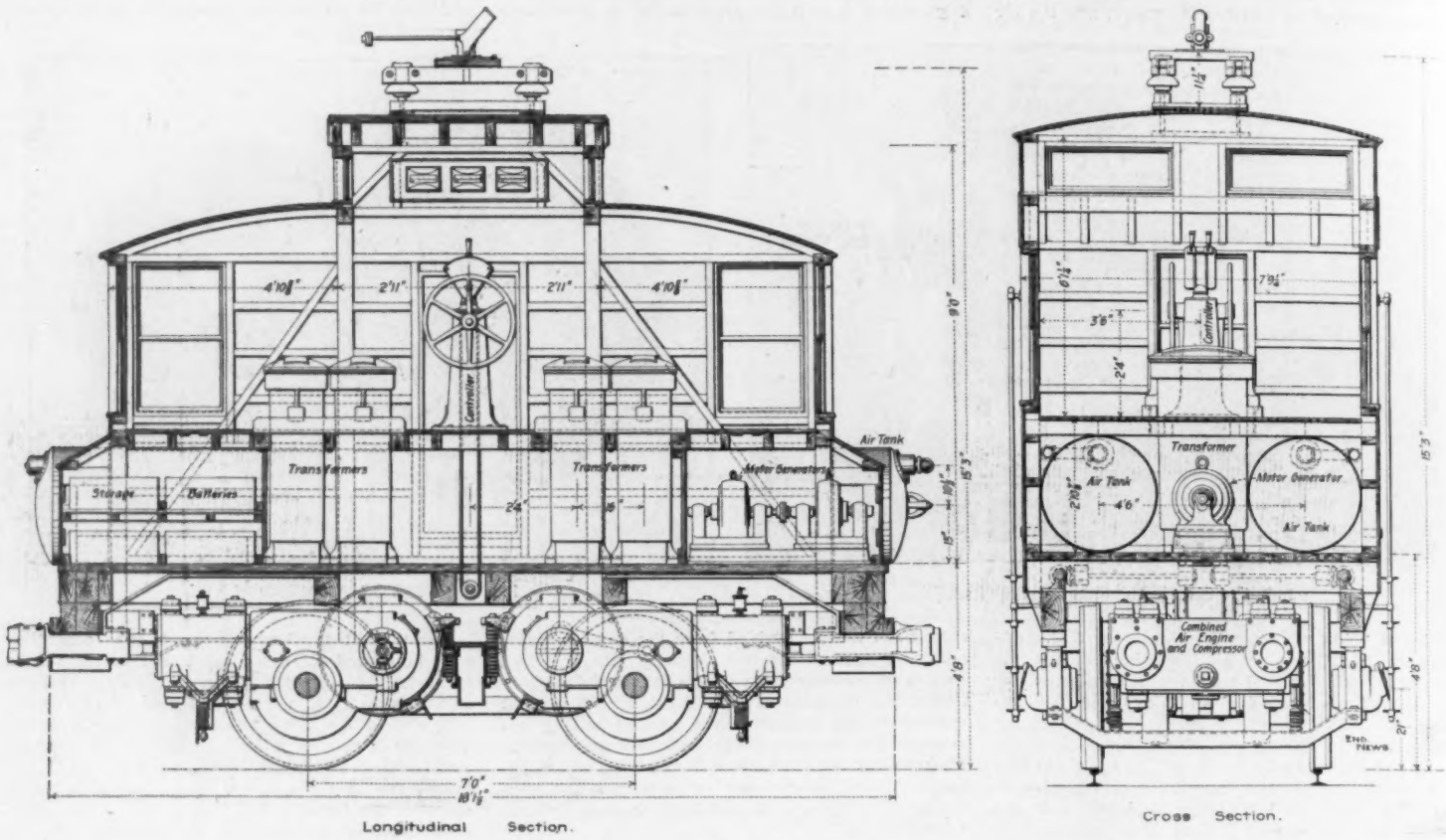
supplied through cylinder S C, and the distance from D L to C R represents the total energy given to the car by the combined action of the electric motor and the stator cylinder when operating under these conditions.

RETARDATION.—To bring the car or train to rest, instead of applying mechanical brakes to the wheels in the ordinary manner and thereby dissipating the entire stored energy of the car or train in the form of heat, this energy is saved in the form of compressed air, to assist in starting the car or train, by setting the controller in such a position that the rotor cylinder compresses air and delivers it into the storage tanks. Any desired rate of retardation can be secured by throttling the delivery pipes from the rotor cylinder and in practice this pipe is provided with an automatic valve which releases just before the slipping point of the wheels, thus allowing the motorman to brake as rapidly as he desires without liability of flattening the wheels. Supplemental wheel brakes are provided for emergency, but need not often be used, and the ordinary wear and tear on them is saved. When the car is again at rest the cycle of performance as above given is repeated for the next run.

REVERSING.—When it is desired to run the car backward for short distances the electric motor is not disturbed and the power is furnished by the rotor cylinder R C by reversing the action of the valves, but if it is desired to run backward for any great distance the current is thrown off the motor, the stator engine reversed, and the stator brought to speed by the air, when the current is again thrown onto the motor, and the cycle of operation is the same as when running forward.

The electric motor used in the experimental work on the Lansing, St. Johns & St. Louis Ry. is shown in Fig. 5, where may be seen the cranks of the stator and rotor, also the collector rings for operating the valves of the air cylinders when working as engines. Fig. 6 shows an interior view of the stator of the motor with the flange removed; the rotor of the motor is of the standard squirrel-cage induction type. To the left in Fig. 5 may be seen the frame and cylinder of one of the air engines. The cylinders are water-jacketed, and the water circulates from one cylinder to the other; thus, when one cylinder is compressing while the other is consuming air, as occurs at all partial speeds, the circulation of the water tends to automatically balance the heating and cooling in the two cylinders.

The single motor and engine first built and tried was too small in capacity to propel a large car; it was therefore decided to experiment with an improvised locomotive, consisting of truck and motor, shown in Fig. 7, carrying suitable air tanks and transformers upon a temporary frame structure. This locomotive was the one upon which the trial runs were made and passengers carried on June 15, 1902 (see Mr. Arnold's letter in the Correspondence columns of this issue). Fig. 8 shows a view of the new double-motor truck constructed after the preliminary experiments had been made on the first motor. For experimental purposes this truck was fitted up in the form of a locomotive, as shown in longitudinal and transverse section by Fig. 9, and it was this locomotive, together with two cars, that was recently destroyed by fire. In order that the locomotive might operate as an independent air unit upon tracks not equipped with overhead electrical conductor it was provided with a small storage battery and small motor generator for charging the batteries and for operating the headlight. These auxiliaries are not necessary for the successful operation of the system, provided the locomotive can always be supplied with electric current from the working conductor, for then the valves can be made to operate from alternating current and thus eliminate the use of motor generator and batteries. When, however, it is desired to operate independently of the electric conductor these auxiliaries are necessary, and one set may supply an entire train.



Longitudinal Section. Cross Section.

FIG. 9. DOUBLE-MOTOR LOCOMOTIVE, LONGITUDINAL AND TRANSVERSE SECTIONS.

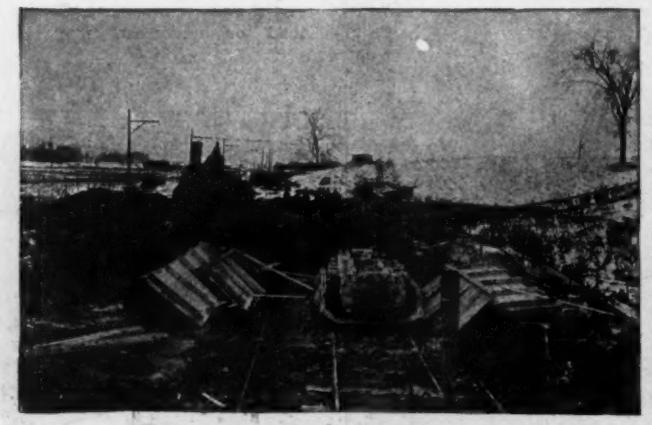


FIG. 10. CAR BARN RUINS AFTER FIRE.

It will be seen that the locomotive is also provided with transformers, another auxiliary which is unnecessary in case the motors are designed for the voltage transmitted over the working conductor. In the present case transformers were used because the manufacturer of the motors could not be induced at the time they were purchased to build a high tension motor for railway work, consequently the parts of a standard motor were utilized, and a pressure of 200 volts adopted for the motors, as this was the most economical voltage that could be used with the particular parts selected. This locomotive was provided with all necessary testing instruments, and had been operated in the barns for some time and found to perform all its functions successfully, and would have been placed on the road and experiments with it would now be in progress had it not been destroyed. All that remains of it is shown in Fig. 10, taken from a photograph of the site soon after the fire. The boards shown were carried to the site after the fire to protect the machine.

A COLLAPSED CONCRETE-STEEL BUILDING.

A three-story department store building of concrete-steel construction in Corning, N. Y., collapsed in part on the morning of Dec. 15. A watchman who was the only person in the building at the time escaped injury. The building had been

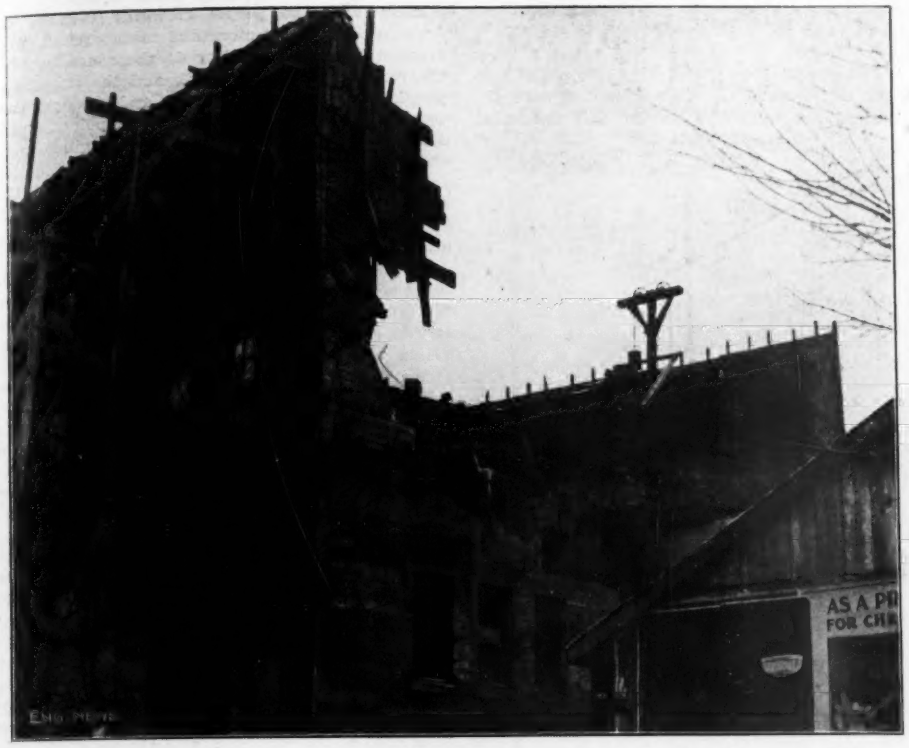


FIG. 1. VIEW OF REAR PORTION OF WING & BOSTWICK BUILDING, SHOWING PART COLLAPSED.

virtually completed, but was not yet occupied. It was being erected for the Wing & Bostwick Co., of Corning, N. Y., on the corner of Bridge and Putteney Sts. Messrs. Pierce & Bickford, of Elmira, N. Y., were the architects. The contractor was Mr. D. J. Calkins, of Columbus, O.; the concrete-steel work had been sublet to the National Concrete-Steel Co., of Pittsburg, Pa.

The floors and walls of this building were of concrete, the floors having a steel wire-mesh fabric inserted as reinforcement. To ensure good workmanship, the architects had provided a clause in their specifications to the effect that the work was to be accepted only after tests, made by the contractor in the presence of the architects; the tests were to be made on sections five feet square, loaded to 400 lbs. per sq. ft. on the first floor, and 200 lbs. per sq. ft. on the second and third floors; at least two sections on each floor were to be tested. Work not standing the test, showing undue deflection, cracks, or other signs of poor workmanship, was to be torn out and replaced, at the contractor's expense, and subject to test before final acceptance.

The first floor concrete had already been tested and found satisfactory; the work on the second and third floors had not yet been tested, and, in fact, it was executed in such manner that the architects believed it would be found unsatisfactory on test. They had already notified the subcontractor's bondsman that the work would probably not pass the tests.

Mr. J. H. Pierce, of the architects for the building, writes us: "We deem the failure entirely attributable to the fact that the reinforcement of the concrete in that part which failed was almost entirely omitted." Concerning the quality of those parts which has been tested, he says "they showed very excellent results," giving exceedingly small deflections under the test loads.

The accompanying photographic views will serve to give some idea of the extent of the failure. The entire rear half of the building, including the rear portion of the floors and the rear wall, collapsed. The reinforcing fabric in the floor concrete is exposed in many places, as may be seen in Fig. 2, in a way that indicates very low cohesive strength in the concrete.

The case forms an object lesson in concrete or concrete-steel work. It emphasizes the fact, already well known to engineers as well as contractors, that concreting, to be satisfactory, must be constructed under constant, thorough and conscientious supervision to ensure that materials, mixture and placing come up to the standard at all points. Indeed, Mr. Pierce himself writes "we would only request that you emphasize the fact that the metal reinforcement has to be properly put in to secure stability and the strength required as prescribed in the tests."

THE CHICAGO THEATER FIRE.

One of the most terrible disasters of recent years was the fire which occurred in the Iroquois Theater, Chicago, during the afternoon performance on Dec. 30. In this fire 586 persons were killed, and about 250 injured, while 100 or more are said to be missing. A startling feature of this great disaster is that its awful effects were accomplished in a comparatively short time and in a fireproof building, which was uninjured structurally, and from the outside shows few signs of the accident. In fact, it requires little more than the work of the decorator to put the theatre in as good condition as it was before the fire. But by a combination of careless management, a stock of inflammable scenery and properties, and a disregard of requirements for fire protection appliances, this fireproof building was converted into a furnace.

FIG. 2. ANOTHER VIEW OF COLLAPSED PORTION FROM REAR.

The theater was an entirely new structure, having been commenced in July last and opened on Nov. 23. It is owned by W. J. Davis and H. J. Powers. The architect was Mr. B. H. Marshall, and the plans of the steel work were prepared by Purdy & Henderson. The general contract was let to the Geo. A. Fuller Co., and the contract for all fireproofing was let to the Roebling Construction Co. All the above are Chicago firms.

The building was of steel-frame construction with brick walls, and a diagram sketch is shown in Fig. 1. It has a 60-ft. front on Randolph St., where is the main entrance, and extends 180 ft. north to the alley between Randolph and Lake Sts. The main entrance is at the south end, the stage at the west side, and the fire escapes on the north end. The auditorium is 70 × 180 ft., and the stage portion 60 × 110 ft. Between the two is a 21-in. brick wall, pierced by the proscenium opening 45 ft. wide. This is spanned by a box girder, fireproofed with 6 ins. of cinder concrete, the outside of which is again covered with metal lath and plaster. The weight upon this girder is reduced by a brick arch in the wall. The 45-ft. opening was reduced to 41 ft. by the decorative proscenium arch, built of metal lath and plaster on vertical steel angles attached to the box girder. There is only one row of columns, and that near the wall, and the two upper floors (the dress circle and the balcony) are carried by cantilever plate girders, with steel beams framed between them. This framing carried a concrete floor, and the steelwork was fireproofed with metal lath and plaster. All this fireproofing is intact except for surface blistering and scaling, although it was exposed to the intense heat of the flame which swept across the house.

The roof is of I-beam rafters and steel T-bar purlins, the latter embedded in 3½ ins. of concrete. There was an open ventilator at the back part of the roof, over the balcony, which served to cause a draft from the stage out into the house.

The main part of the stage had a wooden floor on heavy wooden joists, as concrete is not considered elastic enough for dancing, besides which the floor has to be frequently altered to put in trap doors as needed. The north and south ends, however (beyond the line of the proscenium opening), were of concrete. There was no fire in the basement; all of the fire came from above, and the cinders and wreckage served to protect the wooden floor.

At the south side of the stage were the dressing rooms, the floors of 5-in. concrete and steel beams, the beams being wrapped with wire lath and plastered. The partitions were of vertical steel channels, with wire lath and cement plaster, the thickness being 2 ins. The floors are uninjured, the protection of the beams is only knocked off in a few small pieces, and the partitions are intact. The outer face of the plaster is scaled and broken in places, but the inside face is unaffected. The wood trim and the doors, however, are burned and charred. At this point was the hottest part of the fire, piles of scenery standing

on the stage floor and leaning against the iron railings of the dressing-room floors.

At the southeast corner of the stage proper, close against the proscenium arch, is the elevator, shielded on the north side by a brick wall to the height of the first dressing-room floor, and then by a wire and plaster partition. This partition was but little injured, although some holes were knocked in it, evidently by the streams of water. The decorative proscenium arch was also but little affected, although at the north side (away from the hottest part of the fire) the streams of water from behind had scaled some of the plaster from the wire netting.

At the north end of the stage are two platforms or flys of steel framing with concrete flat arches, the same as the dressing-room floors. A light steel truss bridge (the "paint bridge") against the west wall connects the first "fly" with the first dressing-room floor. At the top, and 7 ft. below the plate girders of the roof (or 12 ft. below the roof), is the "gridiron" from which the scenery is handled. This consists of I-beams attached to steel suspenders from the girders, and these carry rows of transverse small channels. The roof is of similar construction to that of the auditorium, and has in the center a ventilator opening 8 ft. 4 ins. square. On each side of this is a skylight 10 × 23 ft., covered with a wire-glass screen, which is made to slide off, being held closed by a fusible attachment. One of these appears to have opened, but the other remained closed, until the heat was so great that the glass melted out of the frame and fell on the roof girders, over which it hangs in folds like cloth.

These ventilators were supposed to automatically open in case of fire on the stage and afford exit to the flames; but recently published statements are to the effect that these ventilators were propped shut previous to the fire, and that these props were removed and one of the ventilators opened after the fire occurred.

The intensity of the heat in the stage section of the theatre is shown by the warping and distortion of all unprotected ironwork (except the big roof girders). The truss bridge, the gridiron, the roof ladder, and the heater pipes, etc., all show these evidences of heat; but the protected floor-beams and the wire and plaster partitions are to all intents and purposes uninjured.

We may now turn our attention to the stairways and exits, shown in diagram in Fig. 2. The Randolph St. entrance opened into a lobby, beyond which is the foyer or hall, with a 9-ft. wide staircase, A, on each side. These stairways consist of short flights alternating with landings. The right-hand stairway is for persons going to the dress circle (or first balcony), and that on the left for persons going to the gallery (or second balcony). From the top landing of the right-hand stairway a few steps lead to a door, B, giving access direct to the open space behind the seats of the dress circle. A few steps, C, at the side of the landing, lead down to the promenade, D, from which a door, E, opens upon the side aisle. Another door, F, opens upon a spiral stairway which turns at right angles and connects with the lower level of the dress circle. This is for exit only. From the upper landings of the main stairs, other stairs, G, run to a platform, H, followed by steps, J, to upper platform, K. Here a door, L, opens into the lower end of the side aisle, while still another flight of stairs leads to the door, N, opening into the space behind the upper row of seats. At this level is a wide gallery, O, with side galleries extending directly above the stairways, A, but leading to the manager's private offices, which have not yet been fitted up. Of these side galleries, the east one is directly in line with the door, N, and ends in a short flight of stairs to the private door. Naturally a number of people rushed down here, but found the private door locked. One man got through the transom, but could not unlock or break open the door, and a number of people died in this trap. The arrangement of fire escapes on the outside of the building is shown in Fig. 3.

In the dress circle, the door, E, to the promenade was not opened, as is shown by the clean faces of the door and jamb, and the crowd evidently rushed up the aisle along the side wall to the upper door, B. Here they ran against the side of the crowd rushing out along the rear wall, and here the greatest number of dead were found, the bodies piled three and four feet deep and in such a tangled mass that considerable force was required to get them out. This jam, of course, held back the others who were struggling to reach the doorway. The three doors to the fire escape on the other side were apparently not opened, the wood of the meeting parts being perfectly clean. They were not locked, and had no locks, but a lever handle when pulled up pulled out the top and bottom bolts. Possibly somebody fumbled with the door, could not work the handle, and concluded

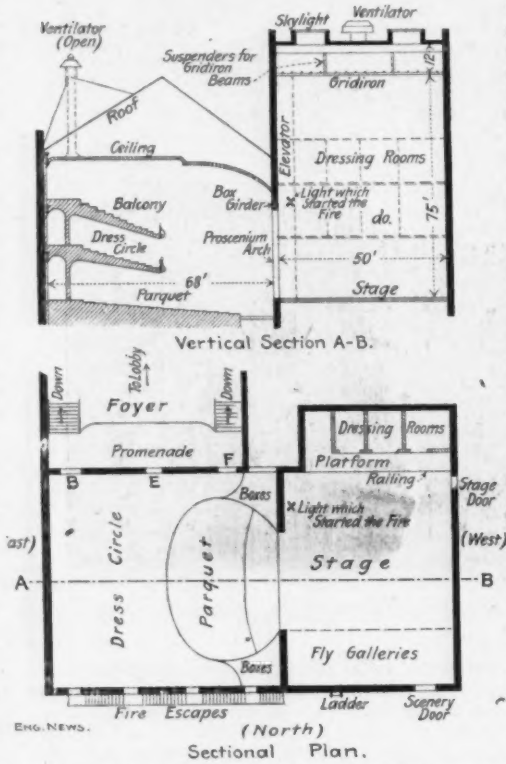


Fig. 1. Sketch Plan and Section of Auditorium and Stage Building of the Iroquois Theatre, Chicago.

that the door was locked, but the natural tendency was for the people to rush to the door by which they had entered. Outside of these fire-escape doors were iron doors or shutters, fastened by hinged crossbars forming latches and operated by a vertical rod connecting them. In the darkness and confusion it was doubtless an awkward matter to open them. At any rate, they were not opened. The balcony fire-escape doors were opened, but with some difficulty, according to report, and persons descending from the upper landing encountered the flame pouring through the door at the lower landing. A few people from this fire escape got across on planks to the building across the alley, but others were killed by the flames before they could get across.

The outbreak of the fire appears to have been about as follows: While an elevated electric arc light at one side of the stage (at X, Fig. 1) was being used to throw a beam of light upon the principal performer as he moved about the stage, a spark from the carbons set fire to the drapery hanging across the top of the proscenium arch. From this it extended rapidly to other draperies and to the overhead scenery and drops, which were of canvas and gauze, painted and highly inflammable. At first an attempt was made to beat out the flame with sticks, as there were no water pails within reach. As the fire spread to other parts some tubes filled with a dry powder extinguisher, "Kilfyre," were tried, but without effect, and the crowded audience then began to start for the doors. The principal actor shouted that there was no immediate danger, hoping to prevent a panic, and the orchestra continued playing for a time. At this time the asbestos fire curtain was lowered, but for some reason it stuck fast before it had fallen half way, and the excited men on the stage could not start it again. There was then a general rush from the stage, and most of the performers escaped without injury. Some went out of the stage door to Dearborn St. and the scenery door to the alley; others went through the basement (where were dressing rooms and the buffet) to the stairs leading up to the lobby.

Meanwhile, the people crowding towards the doors, and growing more and more excited, were blocked by those standing in the space between the rear seats and the wall, and the streams of people coming down the stairs and passages converging to the lobby met at different points, and in the panic they soon formed a struggling mass which could not make headway in any direction and blocked the passage entirely. Some of the doors were closed, the electric lights went out, and the torrents of flame from the stage swept back into the auditorium.

In some modern theaters, a brick shaft is built up from the back of the stage, so that in case of fire it will serve as a flue to carry off the flames and smoke. In the Iroquois Theater no such provision was made, and the skylights in the loft above the stage were closed, while in the roof of the auditorium (at the rear) was an open ventilator. When the stage and rear exits were opened by the escaping performers and stage hands, a tremendous draft was created, which, with the back draft caused by the confined heated air above the stage, carried the flames out through the proscenium arch with such force that they swept through the house and out through the doors into the halls and stairways. In the parquet or orchestra the upholstering of the first row of seats was burned, but behind these there were few signs of fire in this part of the house. The rush of the flame was upward and the rear part of the parquet was shielded by the dress circle above. In the dress circle and the balcony, however, practically all the seats were burned, from the railing clear back to the rear wall, and the paint of walls and ceiling was scorched and blistered by the intense heat.

This terrible disaster appears to have been directly due in the main to reckless and utter disregard of all precautions and requirements as to safety measures and appliances, and to flagrant (or even criminal) carelessness on the part of all concerned, from the managers to the stage hands. This carelessness is made evident in many ways. Some of the stage managers and employees have been held for manslaughter, but the responsibility must reach above them. Had any feature of the decorations been omitted or slighted, there is no doubt but that the owners or managers would have demanded that it be made good. But safety appliances were openly omitted and city ordinances disobeyed with impunity. The building was itself fireproof, but this important safeguard was nullified by filling a part of the building with flimsy inflammable material, and disregarding all considerations of safety. The planned seating capacity was 1,622, but the licensed capacity was in some way increased to over 1,700, and in addition to this some 300 persons were standing in the spaces back of the seats.

We may review here the principal causes of this terrible disaster, resulting from what was at the first but a slight accident:

1. Lack of prompt and determined or efficient action in the first place. The management had a stage fireman (not belonging to the city department), but a good deal of precious time seems to have been lost in confused attempts to get at and extinguish the first blaze. At one time a city fireman was stationed in every theatre during the performance, but the managers objected to the expense. Now it is suggested that their presence be made compulsory.

2. Lack of water pails near the stage. It is reported that the management objected to these as being unnecessary in a fireproof building, and tending to raise thoughts of danger. There were some chemical powder hand grenades, but these were of little if any use. In fact, it is doubtful if the material reached the flames. Water is an important element in fighting fire, and a few pails full promptly and well applied, or the use of an ordinary chemical fire extinguisher, might very likely have prevented the disaster.

3. Failure of the asbestos fire curtain. This curtain was intended to cut off the stage from the body of the theatre in case of fire, but it failed to drop. The man who was usually in charge of it was not in the building at the time, and one employee testified that on account of insufficient counterweights the cable had to be tied, although a slip knot was used so that it could be promptly freed. Others testified that it was not usually dropped clear to the stage, and that its operation had not been satisfactory, but that no alterations had been made to improve it. At a certain stage of the performance an "aerial flight" was to be made by an actress from the stage out into the auditorium, this being by means of a wire from which she is suspended. This would prevent the curtain from falling properly, but the stage management has declared that the wire was not in place at the time. Two reasons are given for the failure of the curtain to fall, the first being that the strong draft from behind bulged it outward, but the most probable story is that a swinging reflector was so placed that it caught and held one end of the curtain as it was being lowered; thus the curtain stopped when one end was about 20 ft. from the floor and the other about 5 ft. It is further alleged that the curtain was of cheap and flimsy construction, and was entirely consumed in the fire.

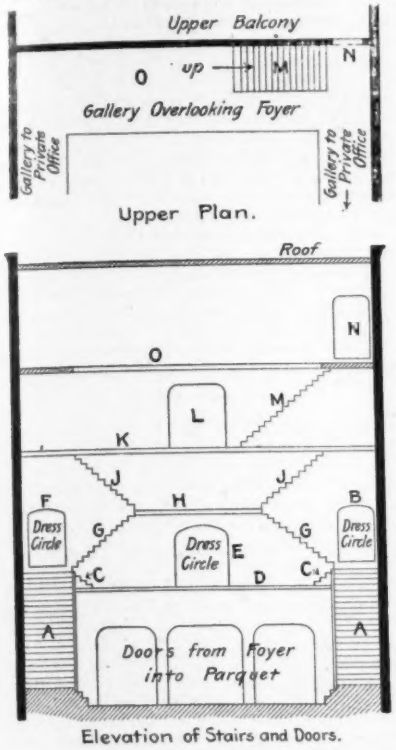


Fig. 2. Sketch Plans and Elevation Showing Arrangement of Stairways and Doors.

4. The closing of some of the exits. While there seems to have been a fair provision of exits, the approaches to them were not convenient in all cases, they were not marked (as required by ordinance), and some of them appear to have been locked. The stage exit to the alley had doors opening inwards, and the people inside blocked it, but fortunately some men on the outside broke or removed the hinges, allowing the doors to fall outward. Of the three exits from the dress circle, two are said to have been locked, and only broken open after the dead and injured had piled against them. It is said to have been the custom to keep these closed until the close of the performance. The unopened (but not locked) doors to the fire escapes have already been noted.

The exits were as follows: (1) Basement (with dressing rooms and buffet under foyer); small rear exit, and stairs from buffet to foyer; (2) stage; one (scenery) door in the alley, and one (stage) door to Dearborn St.; (3) main floor, three double doorways opening into the foyer, and four exits into the alley; (4), balcony, three doorways from south-side aisle towards foyer, and three exits from the other side aisle to an iron stairway fire escape in the alley; (5) gallery, two doors leading to the staircase in front, and three exits to the iron staircase in the alley.

5. Lack of fire alarm facilities. The city building ordinances require the installation of sprinklers and of fire alarm boxes in the theaters. The Iroquois had neither. Yet no complaint or objection had been made by the building department, the fire department or the insurance companies, and the city granted a license for the operation of the theater. There was not even an alarm box in the street within easy reach, and a stage hand had to run a block or more to turn in an alarm, while another alarm was sent by telephone from a drug store.

As to the lesson of this terrible disaster, it is safe to say that similarly dangerous conditions exist to a greater or less extent in nearly every theatre, with the added danger that many of the buildings themselves are far from fireproof. Thus, in the case of the Columbia Theater, in Chicago, which was burned a few years ago, the floors dropped and the whole structure was gutted, but fortunately the fire occurred at a time when the theater was empty.

As already reported in the daily press, the city authorities have taken the radical step of closing every theater but one in the city until they are put in condition to comply with the municipal ordinances. In adition, all halls in the city used for public assemblage were ordered closed on Jan. 4, and it is said the order may be extended to include all churches, factories, stores, hotels and office buildings which do not comply with the municipal ordinances relating to public safety. In many other cities steps are being taken to investigate the condition of theaters and other public buildings, and in Berlin, Germany, by order of the Emperor, the Royal Opera House has been ordered closed until more exits can be built and fireproof stairs substituted for the present wooden stairs.

We append as a matter of record and interest at this time a list of the great theater fires during the past century as published in "The Theater" for January.

Theater in Richmond, Va., 1811; killed, 70; cause, careless hoisting of stage chandelier with lighted candles.
Lehmann Theater, St. Petersburg, 1836; killed, 800; cause, stage lamp hung too high; ignited the stage roof.
Royal Theater, Quebec, 1846; killed, 100; cause, upsetting of a lamp on the stage.
Ducal Theater, Baden, 1847; killed, 63; cause, careless lighting of gas jets in a box ignited draperies.
Teatro degli Aquidotti, Leghorn, 1857; killed, 100; cause, fireworks.
Conway's Theater, Brooklyn, Dec. 5, 1876; killed, 283; cause, border caught fire from border lights.
Theatre Municipal, Nice, 1881; killed, 150; explosion of gas.
Ring Theater, Vienna, Dec. 8, 1881; killed, 875; cause, careless lighting of border lights with alcohol torch.
Circus Ferroni, Russian Poland, 1883; killed, 268; cause, employe smoking.
Opera Comique, Paris, May 25, 1889, killed, 300; cause, scenery ignited from gas jets.
Exeter Theater, England, Sept. 5, 1887; killed, 200; cause, scenery caught fire from gas jets.
Banquet Theater at Oporto, Portugal, March 21, 1888; killed, 240; cause, scenery caught fire from gas jets.

We add to this list the two following:

Front St. Theater, Baltimore, Md., Dec. 25, 1896; killed, 22.
Iroquois, Theater, Chicago, Dec. 30, 1903; killed, 586; cause, spark from arc lamp ignited inflammable scenery.

THE GRAND FORKS WATER-BORNE TYPHOID EPIDEMIC OF 1893-4.

In accordance with a suggestion made by Prof. Gardner S. Williams, M. Am. Soc. C. E., in our correspondence columns, we give below a resumé of the account of a typhoid fever epidemic at Grand Forks, N. D., which was published in Engineering News for May 23, 1895. The original account was included in our description of the slow sand water filters at Grand Forks, and was based mostly on information supplied to us by Mr. W. S. Russell, the engineer for the filters, and at the time the city engineer of Grand Forks.

Mr. Russell stated that there had always been more or less typhoid fever in Grand Forks, but no alarm was caused until the outbreak of 1893-4. There were, however, no records of typhoid fever prior to the fall of 1893, and no board of health until Jan. 1, 1894. In November, 1893, it is known that there were two cases of typhoid fever; no deaths were reported. In December there were 230 cases and 4 deaths; January, 712 cases and 52 deaths; February, 231 cases and 27 deaths; March 46 cases and 11 deaths; April, 26 cases and 2 deaths; making a total, for five* months, of 1,245 cases and 96 deaths.

As to the cause of this epidemic, Mr. Russell stated:

> The cause of our epidemic was undoubtedly directly attributable to a lesser one at Crookston, Minn., which is situated on the Red Lake River, about 60 miles above us by river. The best information which I can obtain is from the physicians and health officer in Crookston, which shows that they had in their city during October and November, 1893, something over 60 cases of typhoid fever. In the fall of 1892 the main sewer in Crookston, there being but one main, was broken down and completely stopped by the settlement of the railway embankment. From that time to Nov. 16, 1893, the effluent was pumped from their sewers over the embankment into the river with a 4-in. centrifugal pump, which was so placed that it was impossible to remove much, if any, of the sludge. On the last-named date, at which time the river was frozen over solid, the city completed a new outlet for their sewers. On Nov. 17 the entire sewer system of Crookston was flushed, and the above record, kept by our Board of Health, I believe shows the result.

The water supply of Grand Forks, at the time of the epidemic, was taken from the Red Lake River, and was not filtered. Analysis of the water in question, made during the epidemic by Prof. Victor C. Vaughan, of Ann Arbor, Mich., and by other chemists and bacteriologists, resulted in its condemnation as unfit for drinking purposes.

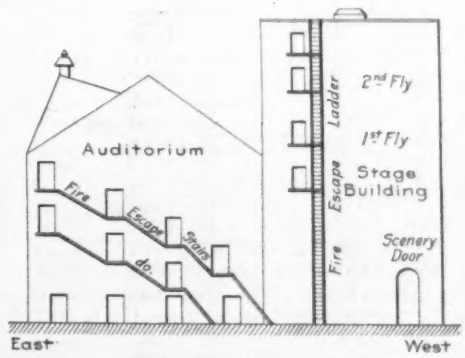


Fig. 3. North End Elevation of Iroquois Theatre, Showing Arrangement of Fire Escapes.

Following the epidemic, and largely because of it, although proposed before, a filtration plant was built in the latter part of 1894 and put in operation on Jan. 4, 1895.

A TOOL FOR REMOVING BROKEN TAPS.

The vexatious job of drilling out a tap that is broken off in the hole being tapped may be avoided by using the tool shown in the cut accompanying. The tool provides a set of fingers which can be slid forward to engage the grooves in the tap

*Professor Williams' letter purports to give the totals for four months, but his figures correspond with ours for five months.

and thereby serve to screw the tap out by way of the threads already cut. The tool is made by the Atlas Machine Co., of Providence, R. I., to whom we are indebted for the accompanying cut.

The body of the tool is a round rod of diameter about equal to the hole being tapped. Longitudinal grooves in the rod form seats for sliding fingers which are all fastened at their outer end to a sliding collar. Below this collar is a sliding sleeve, which can be slid down close to the face of the work to give support to the fingers.

A Tool for Removing Broken Taps.

To use the tool, the end is pushed into the hole, the fingers slid forward into the grooves of the tap by means of the outer collar, the sleeve slid down close to the work, and the tap screwed out by means of a wrench set on the squared outer end of the tool.

THE EFFECT ON THE TENSILE STRENGTH OF CEMENT OF REMOVING BRIQUETTES FROM WATER FOR VARYING LENGTHS OF TIME BEFORE BREAKING.

By J. L. Van Ornum,* M. Am. Soc. C. E.

The writer wishes to give some results of laboratory experiments in order to emphasize the necessity for standard and uniform methods in testing cements. This particular investigation was undertaken because of the fact that in testing a certain brand of cement, briquettes that were broken immediately when taken from the water bath in the laboratory gave very different strengths from some of the same age that were brought to the laboratory and broken when dry. In consequence Mr. E. F. Sessinghaus took for his graduation thesis in the Civil Engineering Department of Washington University the subject, "The Determination of the Effect (on the Tensile Strength of Cement) of Removing Briquettes from Water for Varying Lengths of Time Before Breaking Them." In his thesis Mr. Sessinghaus says:

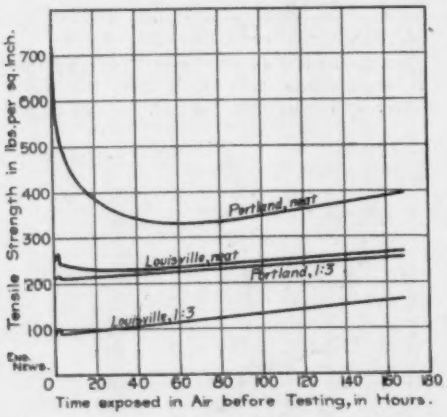


Diagram Showing Effect on Strength of Cement Briquettes of Time of Exposure in Air Before Breaking.

The tests were made upon one standard Portland cement and upon one standard natural cement; nearly 800 tests were made. The briquettes were broken seven days, 28 days, three months and six months after they were made, and had an exposure to the air before they were broken of zero hours, one hour, three hours, 24 hours, 72 hours, and 168 hours.

The neat briquettes of Portland cement fall off rapidly in their tensile strength when exposed to the air, having a minimum strength of about half for an exposure of between 24 hours and 72 hours, after which they gradually and slowly become stronger again.

The exposure to the air of the 1 to 3 mixture of cement and sand causes no loss of tensile strength, but a gradual increase as the time of exposure becomes greater. The proportion of 1 cement to 3 sand is the only one which gave a higher tensile strength by allowing the briquettes to stand in air before testing them. This seems to show that adding greater proportions of sand lessens the effect of the weakening of the tensile strength due to exposure.

Like the Portland neat briquettes, the Louisville cement neat briquettes decrease in tensile strength upon standing in the air for about the first 72 hours, and then gradually strengthen. The percentage of loss for the first few hours of the drying out is, however, not nearly as great as in the case with the Portland neat.

The accompanying figure represents typical curves of the behavior above referred to. The mixtures of 1 cement to 1 sand and 1 cement to 2 sand showed, as would be expected, conditions intermediate between the results above given for the neat briquettes and the 1 cement to 3 sand. In the sand mixtures the writer has occasionally found a very considerable additional strength evident upon allowing the briquettes to dry a few hours before breaking them. The need of standard specifications and practice in this regard is hence evident.

*Professor of Civil Engineering, Washington University, St. Louis, Mo.

THE CEMENT PLANT built by the Government at the Tonto dam site in Arizona, may not be used after all. The dam is to be one of the largest in the world, and it is roughly estimated that some 200,000 bbls. of cement will be required. The dam site is some 40 miles from the nearest railway station at Globe, and the long rail haul from the California mills added to the team haul to the dam site was believed to make the cost so high that it would be cheaper to build a cement plant at the dam site, where excellent cement materials are found. This has been done, but a strong protest was made by the cement manufacturers on the ground that the Government had no business to engage in cement manufacture in competition with private concerns. The Government officials, therefore, informed the cement makers that if they could supply the cement cheaper than it could be made on the site, the cement plant would not be used. Bids for cement were therefore advertised for, and were opened on Jan. 4, when a price of $4.80 per bbl. delivered at Globe, 40 miles from the dam, was bid. This is a reduction of $2 per bbl. from the price previously charged at Globe. If it is found from this figure that cement can be delivered at the dam cheaper than it can be made there, the plant at the dam will not be operated. The expense of manufacturing cement at the dam site is largely affected by the fact that the fuel must be brought in from as great a distance as the cement; and even with the use of oil fuel, the fuel will weigh a third as much as the cement which it will make.

WATER SOFTENING PLANTS FOR WESTERN RAILways is the subject of an interesting statement recently made by the U. S. Geological Survey, substantially as follows:

On the Middle Division of the Atchison, Topeka & Santa Fe Railway System there are 29 water stations. The locomotives passing these stations use, on an average, about 999,000 gallons of water daily. The water from nearly all these sources contains encrusting constituents, that is, the sulphates and carbonates of lime and magnesium, and, in many cases, corrosive substances such as chloride of calcium and magnesium are present in troublesome amounts.

The encrusting solids contained in the 999,000 gallons of water used each day in the year amount to over 3,200 lbs., or, in the course of a year, nearly 590 tons. The removal of this (from the boilers.—Ed.) would cost probably from 6 to 10 cts. per mile of distance run.

At these 29 water stations water softeners have been erected at great initial expense. The maintenance of these softeners requires the expenditure of about $17 per day for chemicals, and an additional charge of about $58 per day for services of attendants, making a total of $75 per day, or $27,375 per year. The cost of construction of these water softeners was not made public, but if the cost of maintenance represents 4% on the investment the total amount expended for water softeners is nearly $700,000.

It has been demonstrated that it is cheaper in the case of the Middle Division of the Atchison, Topeka & Santa Fe Ry. to expend $27,375 a year for softening water used in locomotives than it is to supply these locomotives with the raw water. These figures are instructive, as they show the expense and trouble to which a railroad must be subjected in case waters suitable for boiler purposes cannot be found.

The same experience holds true on other railroads. At ten water stations along the Union Pacific there is removed from the water used in locomotives 2,790 lbs. of solids per day, almost as much as is removed from the water of 29 stations along the Santa Fe system, although at the ten Union Pacific water stations, they use about 50% more water than at the 29 Santa Fe stations.

The chemical survey of natural waters which is being made by the Geological Survey, through its Division of Hydro-Economics, is directed, in part, toward the location of available waters which may be used for boiler purposes without treatment. If by extensive surveys such waters can be discovered and their location made known, the saving of a tremendous amount of money will be effected, and, as in the case of railroads, the cause of such great losses is largely due to lack of information concerning the source of waters suitable for boilers, the railroads of the country will be the greatest beneficiaries of this phase of the work of the Division of Hydro-Economics.

LABORATORY EXPERIMENTS ON MATERIALS FOR tar macadam pavements are to be made at Duluth, Minn., under the direction of Mr. W. B. Patton, City Engineer. Mr. Patton informs us that an effort will be made to ascertain the best mixture of different sizes of crushed rock, and also to test several proposed bituminous mixtures as to their behavior at different temperatures.

TYPHOID FEVER HAS CAUSED UNUSUAL ALARM in a number of cities during the past few weeks. First of all, it may be mentioned that to the close of December the epidemic at Butler, Pa., had resulted in about 85 deaths, and while the deaths had fallen off somewhat new cases were still being reported with frequency.——Pittsburg appears to have had more cases of typhoid in December than in any previous month on record. The exact figures are not available, but up to Dec. 22 there had been 410 cases, with 49 on the last day of the record. On four later days in December the cases ranged from 34 to 14, and aggregated 86, making 496 cases for 26 of the 31 days in the month. In December, 1902, the total number of typhoid cases was 108.——On Jan. 4 it was reported that there were about a hundred cases of typhoid at Kittaning, a place having a population of 3,902 in 1900, located on the Allegheny River above Pittsburg.——In Philadelphia 131 cases of typhoid were reported during the week ending at noon, Dec. 26. These were attributed chiefly to the water supply from the Schuylkill River.——At Passaic, N. J., some 30 cases of typhoid fever were reported in a single week in the latter part of December; these were confined to one section of the city and were attributed to the milk supply, rather than the water supply.——At Orange, N. J., and Norwalk, Conn., recent outbreaks of typhoid were perhaps due to oysters from sewage polluted waters.

THE POLLUTION OF LAKE CHAMPLAIN BY PULP mill refuse is to be investigated by Col. Wm. S. Stanton, U. S. Corps of Engineers, acting under orders from the Secretary of War. The New York State Board of Health ordered an investigation of the same matter some months ago, but its report has not yet been made.

PNEUMONIA CAUSED 139 DEATHS IN CHICAGO during the week ending Dec. 26, or 27% of the total mortality. During the same weeks there were only 49 deaths from consumption, or less than 10% of the total mortality. These figures are very significant when it is remembered that pneumonia is now classed with the communicable diseases and that consumption once headed the list of communicable diseases. For some years past the percentage of mortality from consumption has been decreasing, while that from pneumonia has been increasing.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was the derailment of a fast through passenger train on the Lake Shore & Michigan Southern Ry. at Ashtabula, O., on Dec. 31. The eastbound "Lake Shore Limited" from Chicago to New York was behind time and was running through the yards west of Ashtabula at high speed, when it struck an open switch and left the rails. The train was double-headed, and both engineers and one fireman were killed. The switch was interlocked with its signal, but a heavy snowstorm was raging and it is supposed the engineers did not see the stop signal. It is noteworthy that of the two or three other railway accidents with fatal results which occurred in the past week, two were derailments, one being due to an open switch as in case of the Lake Shore wreck. A passenger train on the Cumberland Valley R. R. was derailed at a switch near Newville, Pa., on Jan. 1, and at least one death resulted. A train on the Western Maryland R. R. jumped the track near Blue Mountain, Md., on Jan. 3, and two persons were killed.

AN ACETYLENE EXPLOSION in an inn at Keasbey, N. J., on Jan. 3 wrecked a building in which a reception was being held and injured a large number of the occupants. It is not known how the explosion was caused. The building was illuminated by acetylene from a generator and tank in the basement.

TRACK ELEVATION IN CHICAGO has made good progress during 1903, according to the annual report made to the mayor by Mr. John O'Neil, Superintendent of Track Elevation. During the year there were 74.75 miles of track elevated (of which 8.25 miles were main track), and 41 subways built, at a cost of $3,165,250. The work planned, completed and remaining to be done is shown by the following table, compiled from the figures of the report. It will be seen that nearly half the work yet remains to be done:

	Work as planned.	Work done, May, 1892, to Dec. 31, 1903.	Work yet to be done.
Miles of main tracks elevated	138.10	80.67	57.43
Miles of other tracks elevated	709.95	420.19	289.76
Miles of total track elevated	848.05	500.86	347.19
No of subways	537	351	186
Estimated cost	$43,540,250	$25,445,250	$18,095,000

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